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Science and Technology in National Development Plans:...

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Science and Technology in National Development Plans:Some Case Studies (Brazil,Indonesia,Korea,Nigeria, and Turkey).Michael J. Moravcsik.Apr.1973.

111 p.

Prepared for Symposium on Incorporation of Scientific and Technological Considerations in Development Planning,Washington, D.C.April 30,1973.

1.Development planning.2.Science and Technology. I.Moravcsik.II.Brazil. III.Indonesia.IV.Korea. V.Nigeria.VI.Turkey.

SCIENCE AND TECHNOLOGY IN NATIONAL DEVELOPMENT PLANS: SOME CASE STUDIES (Brazil, Indonesia, Korea, Nigeria and Turkey)

by

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I. INTRODUCTION

With the advent of Big Science in the 1940's the pursuit of science (throughout this study "science" will denote the natural sciences) and the involvement in the resulting technology became necessarily part of the national policy of every country then involved in research at all, regardless whether its basic economic structure was based on private capital, government monopoly, or some scheme in between. This was the result of the realization that even if some of the scientific and technological research activity is extragovernmental in sponsorship and execution, there are other, large areas of research which require collective resources and manpower. Furthermore, even the extragovernmental research benefits from being included in the over-all coordination of a country's research activities. Thus, science policy as part of the national policy has acquired a permanent place.

As, after the Second World War, the number of newly independent countries multiplied percipitously, and they, as well as other countries previously scientifically dormant, began to generate some scientific activity, such activity almost automatically became part of their national policy, even though at the beginning not in a very explicit manner. In most of such countries private capital was in short supply, and the educated fraction of the population, capable of being involved in scientific and technological activities, was naturally gathered around or in the government.

The actual, formal inclusion of such activities into governmental planning and policy formation occurred gradually, partly as the amount of activity became noticeable, partly as a matter of conforming with increasingly popular

This paper was commissioned by the Agency for International Development for a symposium entitled "The Incorporation of Scientific and Technological Considerations into Development Planning", held in Washington, D.C. on April 30, 1973.

worldwide customs, and partly because science and technology also represents a prestige symbol, and hence should be displayed in important documents such as development plans.

The aim of the present study is to analyze the science and technology component of the development plans of a few selected countries. It follows from what was said above, that in many cases such a task is almost equivalent to the analysis of the total scientific and technological activity in the country. Yet, the present study will approach the subject specifically through the development plans, and invoke additional sources only when the corresponding information is not available from the plans themselves.

The analysis will be primarily descriptive, though intermixed with some evaluative elements. The latter is a difficult task, as it will be explained in the next section, not so much because all relevant information might not be available, but because of the methodology of evaluation is, even theoretically, incomplete. Yet, the study will attempt to arrive at least at some conclusions designed to serve as a feedback into future planning of science in these and other countries.

The overall outline of the study is as follows. After the preliminary comments of this section, the second section is devoted to the general methodology of the analysis of scientific and technological activities, discussing both theoretical problems and operational procedures. The third section then will apply these considerations to five countries. Finally, the fourth section will derive some conclusions.

The countries selected for this study represent an interesting sample which exhibits a variety along several dimensions. The list includes (in alphabetical order) Brazil, Indonesia, the Republic of Korea, Nigeria and Turkey.

Though very tiny countries are not included, those on the list cover a wide range of sizes of populations. They also cover virtually the whole span of per capita GNP's among the countries conventionally referred to as "less developed". Geographically, they represent four continents. They are also spread over a fairly large range as far as the stage of scientific and technological development is concerned. Finally, they exhibit a variety of cultural backgrounds, past colonial associations (or the lack of it), and economic structures. Thus, on the whole, these five countries allow us to get a meaningful glimpse into the position science and technology has in the national development of less advanced countries.

II. METHODOLOGY

In principle, science and technology, like many other areas, can be regarded as an input-output problem (Freeman 1969b). According to this view, which will basically be adopted in this study also, science and technology can be measured by the amount of money, material, and manpower invested into it, and then by the total value of the product resulting, as an output, from the input of the above ingredients. As is often the case with general ideas, the difficulty arises when we try to convert this simple and appealing conception into a set of operational procedures for performing the measurement of the input and the output. An excellent and recent review of this subject is given in Freeman (1969b).

It turns out that the measurement of the input is by far the easier part of the problem, and in fact a rather detailed handbook for measuring scientific and technological activity, dealing mainly with input, has been proposed (Freeman 1969a). There are some unsolved problems in this area also, such as the classification of various data into categories which are internationally comparable, the actual collection of the data in an environment where such a census has never been undertaken before, etc. But on the whole, the input problem is fairly well under control. It is not too surprizing, therefore, if virtually all of the detailed and quantified elements of the development plans pertain to input, or to the creation of future input. In contrast, Freeman (1969b, p. 8) states that "The position with regard to measurement of R and D outputs is completely different. There is no nationally agreed system of output measurement, still less any international system. Nor does it seem likely that there will be any such system for some time to come. At the most, it may be hoped that more systematic statistics might become possible in a decade or two."

In part, the problem lies in the nature of the output of science and technology: The products are intangible and not easily amenable to statistical measurement. Scientific discoveries, technological inventions, or even the creation of functional groups of scientists or technologists with a potential for such discoveries and inventions are difficult to measure.

Some progress has been made in trying to find such measures. In the sciences, counts of publications and citations of publications have developed into an interesting tool which has produced some well defined results, mostly through the advocacy, expertise, and energy of De Solla Price (see for example Price (1969). In the present study I will make use of this tool. With respect to technology, the count of patents might serve as a measure, at least in that part of the world where this concept has a meaning. This tool is discussed in Freeman (1969b).

There are, however, both conceptual and practical difficulties connected with these measures, as discussed by Freeman (1969b) and by an earlier paper of mine (Moravcsik 1972). I will merely mention two of these. One pertains to the uncertainty as to exactly what one wants to measure in the output. Activity is not the same as productivity, and even productivity is not necessarily the same as progress. Yet it is productivity and, even better, progress that one ultimately aspires to when encouraging scientific or technological activity, while the above measures pertain mainly to the quantification of activity. The difference between these is what spoils one of the simplest prescriptions for the measurement of output: To take it simply proportional to the input. Perhaps the output activity is to some extent proportional to the input, but in the measuring of productivity or progress, efficiency factors and other, more organic considerations enter which cannot be hypothesized, at least a priori, to be the same for all countries under all conditions and in all areas of science and technology.

Related to this first difficulty is the second one, which is more general in as much as it pertains to both input and output. It is the distinction between quantity and quality. This subject was eloquently discussed in the context of the less developed countries by Sabato (1970). Simple counts of money, man, material, publications, citations, or patents tend to be primarily measures of quantity, and their power to indicate also quality is at least questionable. At the same time, it is often quality and not quantity that is the most crucial missing ingredient in science and technology in the less developed countries. It is quite possible to judge quality, but the method of judgement is non-quantitative, somewhat subjective, and relies on certain assumptions which contain the seeds of vicious circles in logic: One can simply retain a sufficiently large group of international scientists and technologists for a sufficiently long time so as to acquire a sound knowledge of the scientific and technological accomplishments of the particular country, and then take a statistical survey of their personal assessments. Some such assessment is in fact the basis of the personal evaluation that single individuals arrive at through their direct experience in some countries and through conversations of colleagues who had such experience.

Such a personal evaluation is, however, seldom both extensive and intensive. In my own case, I would be reluctant to give too much weight to such a personal evaluation in connection with the countries under discussion. Though I have some second-hand information about all five, it is not very extensive, and my personal acquaintance with these countries through actual visits on the spot is limited to only two out of the five, and only for relatively short periods of time. Thus, while such personal impressions might play some role in this study, they do not form a major part of it.

Having dwelled on some of the conceptual and practical difficulties of evaluation the science and technology components of development plans, I will now, nevertheless, outline the procedure that will be followed in these case studies when I will analyze the input and output.

The discussion of the input will be divided into six parts. First we will study the scientific and technological manpower situation, including the educational opportunities in these areas, the employment picture, and the brain drain. Next, we will turn to the funding of science and technology, followed by a survey of auxiliary services such as shops, libraries and other information centers. We will then discuss the organizational structure of science and technology and the policy-making bodies. This will be followed by a discussion of the extent to which science and technology is successfully interfaced with developmental and industrial activities. Finally we will discuss international connections, that is, bilateral links, regional activities, participation in international organizations, etc.

The discussion of the output will, by necessity, be much shorter and will deal mainly with publication and patent information.

It will be evident from the discussion in Section III that much more information was available to me about some of the countries under investigation than about others. I am quite certain that some of this disparity is due to my own inability to get hold of all the available information during the relatively short time interval that was at my disposal to prepare this study. I am also sure, however, that at least as important a factor in this disparity is the substantial differences existing between various countries in the extent of the information gathered about them either by international organizations or by the countries themselves. This disparity is in itself an indicator of the differing stages of these countries as far as their ability for planning science and technology is concerned.

III. APPLICATION TO CASE STUDIES

A. General Comparative Statistics

To place the study of science and technology in these countries into a proper general context, Table 1 gives some general comparative statistics about the five countries under consideration. Areawise the countries range from the enormous Brazil to the relatively tiny South Korea. The population growth in all countries has been rapid, roughly 30% in a decade. Note that the population figures obtained from the two different sources for Nigeria do not connect in a reasonable way. Literacy rates range from a low 25% for Nigeria to a high of 71% for Korea. All countries for which such statistics is available show a rapid trend toward urbanization. The per capita GNPs range from a very low of $105 (almost the lowest of all countries in the world) to about $400, which is not very far from the (somewhat arbitrary) limit of $500 that some use to define as the division between a less developed country and one that bears an at least qualitative resemblance in development patterns to a so-called advanced country.

The distribution of domestic products shows that Nigeria and Indonesia are still half agricultural, with industry being only about 10%, while in the most advanced Brazil agriculture represents only one-fifth of the domestic product.

Some advocate the per capita production of electricity as a good development indicator. According to it, there are factors of 25 among the countries under consideration. On the other hand, interestingly the fraction of national income spent on education, which also varies among these countries up to a factor of five, is not at all correlated with the other developmental indices mentioned above.

Some additional comparative information is given in Tables 2-6, mainly from UNESCO (1970b) which, unfortunately, is very far from being complete. In fact, only Korea and Nigeria are covered of the five countries under consideration, though I added in those tables some information from other sources. In the educational area, we see that Korea produces about 30-60 times as many graduates in science and technology as Nigeria, but percentagewise, Nigeria's improvements has been faster. The percentage distribution by field or specialization is not very different from the two countries.

Finally, Table 7 provides a general outline of the development plans of these countries. Brazil and Indonesia are just beginning to plan, while the other three countries have had development plans since the early sixties. The per capita GNP targets represent a projected 6% increase per year for Brazil and Turkey, 4% for Nigeria, 8% for South Korea. The Indonesian plan contains no target information for such general economic indicators.

The above information will be supplemented by additional specific data for each country and each entity in the subsequent discussion.

B. Scientific and Technological Manpower

Brazil

The plan says little about the quantitative aspects of manpower development. General targets of university expansion are given in Table 9, indicating a factor of two between 1970 and 1974. The plan, on p. 43, also gives a total targeted figure for the total educational expenditure (public and private) for the three-year period of the plan as Cr$ 31.2 billion, about 90% of which is in the public sector.

The size of the manpower as of the late 1960's is given to some extent in UNESCO (1969b), p. 90, which gives the number of professionals "at the superior level", as of 1967, as 32,000 engineers, 42,000 doctors, 2,000 industrial chemists, 7,500 agronomists, and 3,500 veterinarians. Some indication of the number of scholarships given out in the sciences by the CNPq (see later) is given in Table 12.

A number of qualitative recommendations were listed in National Academy (1969b), pp. 10 ff., with respect to science and technology education. It included accreditation committees, summer refresher courses, improved contact with industry, joint theses with industry, the serving of university staff as consultants in industry, etc. There was also a set of recommendations (pp. 16 ff) concerning a model of an industrial research institute, including among other things contract research for industry.

In connection with manpower development in Brazil, one must also mention the big chemistry project managed in cooperation by the Brazilian government and the U.S. National Academy of Sciences. For a description of the general idea, see CEN (1970). The program involves the temporary transplantation of a large number of American chemical researchers into Brazilian counterparts, performing both research and training.

This concentrated approach of scientific manpower training and research is an expensive project, amounting to several million dollars over its lifetime. Its success will not be able to be evaluated until the time comes for the American contingent to withdraw and the Brazilian personnel to take over the operation.

Information on the Brazilian brain drain came to me primarily from CIMT (1970), though in it there is a reference to some Brazilian studies also (which I could not use). CIMT (1970) treats Brazil only together with all other Latin American countries, but at least in that context it would appear (see Tables 10 and 11) that the brain drain from Brazil is at least quantitatively very small.

Indonesia

The Indonesian plan reflects in all of its aspects the fact that the immediate task is to regain the ground lost in the 60's due to the mismanagement of the previous government. This is for example evident in the only four numbers in the plan pertaining to scientific and technological manpower development: In Volume 1, p. 28, the SMP in comparison with secondary technical schools/vocational schools is given for 1969/70 together with the target of 1973/74. The figures are 100:80 (1967) and 100:98. The same figures for SMA in comparison with technical high schools/vocational schools are 100:84 and 100:112.

The remainder of the manpower discussion in the plan is basically a qualitative one. In Volume 2c, p. 22, higher education is listed as due for rehabilitation particularly in the exact science faculties, and the feeder exact science faculties are promised equipment and laboratory facilities by 1972. Curricular changes are also mentioned. On p. 129, it is reported that the total number of graduates from 24 out of the 40 state universities between 1950 and 1967 was

11,050 in the exact sciences, 9,345 in the non-exact sciences, and 1,417 in the teaching sciences, all quite negligible numbers for a nation of a hundred million. In fact, shortages exist in all aspects of scientific and technological activity. On p. 130 it is reported that 20 research institutes which returned a questionnaire (it is not mentioned what fraction that is of all research institutes) have altogether 645 research workers, 12 in medicine, 86 in physical sciences, 433 in technical science, 13 in agriculture, 6 in social sciences, and 97 miscellaneous. Some general remarks are made on p. 139 recognizing the long range connection between education in the schools and the availability of scientific manpower.

Korea

In contrast with the skimpy and qualitative manpower discussion of the Indonesian plan, Korea presents a varitable flood of manpower statistics, analysis, and extrapolation. The situation in the late 50's and early 60's is briefly discussed in UNESCO (1961), p. 20. Later information is given in Tables 14-23, which also specify the targets of the plan. In addition, Korea has done some very long range planning also, up to the late 80's. The manpower aspects of this are summarized in Table 24. It should be mentioned, however, that the rather extensive statistics available about Korea is not always self-consistent.

The above material reveals an interesting situation. For some time in the past, as well as in the present and in the near future, the scientist and engineer manpower trained in Korea exceeds the demand, in some cases by a large amount. It is, however, claimed that this temporary excess is necessary to satisfy the expected huge demand in the mid-80's, and simply reflects the fact that the maximum possible rate of the growth of education is smaller than that of manpower demand, and hence long range planning is necessary. The plan, however, does not seem to discuss the problem of providing employment and motivation for the excess manpower until the time comes for them to be usefully absorbed into the scientific and technological system.

The above excess of manpower is, however, not expected to occur with respect to technicians. On the contrary, huge shortages are predicted, which might be somewhat alleviated by drawing personnel from two-year colleges.

The brain drain with respect to Korea is discussed in some detail in CIMT (1970), which also emphasizes that whereas there are quantitative excesses in Korean manpower in science and technology, there is also a shortage in qualitatively superior manpower. Certain key positions remain unfilled, and in fact the plan itself also emphasizes a greater stress on quality in future educational activities. There are, however, no specifications as to how this should be accomplished.

Data on Korean brain drain is given in Tables 25 and 26. One can see that whereas the absolute numbers are not at all negligible, in a fractional sense the drain is not very large. Here also, however, quality must be considered, and though information is not given on this point, one suspects that, as usual, the drain affects more the top quality personnel. From a different point of view, however, one can optimistically say that the drain provides a temporary storage place for Korean scientific and technological manpower until the projected science and technology boom developes in the 1980's which then might be able to re-attract this personnel.

<u>Nigeria</u>

In contrast to Korea, no excess manpower appears anywhere on the Nigerian horizon. The absolute numbers of scientific and technological manpower are tiny, as shown by

Tables 4, 6 and 40. Present and projected manpower shortages, in fact, necessitate the continued retention of non-Nigerians in the scientific and technological manpower pool, inspite of a definite policy of indiginisation.

A listing of Nigerian higher educational institutions is given in UNESCO (1966), but no quantitative details are appended. The list does include, however, also research and service organizations.

The plan itself aims at a quantitative expansion of the training facilities for scientific and technological manpower, as well at some reorientation of emphasis. For example, it is pointed out (p. 316) that while professional and managerial personnel should be supported by intermediate category of workers at a ratio of 1:3 or less, the present ratio of university output to that of the technical institutes is 2:1. Thus much emphasis is planned on technical institutes. During the plan period, however, the universities are also going to expand to an additional capacity of 7,000 students (in all areas).

An interesting remark (p. 316) pertains to the desired ratio of Science and Technology and the Humanities at a university level. The present target is 50:50, and it is remarked that inspite of the conspicuous need for scientists and technicans, the ratio should not go beyond 60:40 in any case, because of the equally acute shortage in the managerial and administrative categories of high-level manpower.

Turkey

While Turkey's manpower pool is much better developed than that of Nigeria, no excesses are recorded or forecast there either. The situation in the 50's is briefly summarized in UNESCO (1961), p. 22, according to which the number of engineers, architects and agricultural professionals was 6,200 in 1950 and 10,000 in 1958.

More recent statistics, targets for the plan, and long term projections are given in Tables 44-51. In addition, some data are also given in Okyar (1968b), pp. 221 and 223. The latter predicted serious shortages for 1972 in engineering as well as other areas, amounting to 50% in some areas. This is correlated, to some extent, with the shift of Turkish students at the universities from science and engineering to humanities and social sciences, though recent statistics on this point is not given. Turkey, like Korea, has some very long term projections also, up to 1982. An interesting estimate is given in Table 46 concerning the cost per student of education in various areas, showing that training in the technical fields (including sciences) is about 50% more expensive than in medicine or agriculture, and 2-1/2 times more expensive than in other areas of university offerings.

Some information concerning manpower in actual research is available from OECD (1969), and is given in Tables 47 and 48. Rather extensive additional information is also available in OZINONU (1969), which is also the source of Figure 1.

Brain drain from Turkey is treated in some detail in CIMT (1970). Though the statistical information is not as complete as one might desire it, we know, for example, that between 1962 and 1966, some 16% of the graduates from Turkish universities in the natural sciences emigrated (p. 301). The situation for engineers is illustrated in Table 49, showing a smaller but not negligible loss to emigration.

C. Funding

Brazil

Expenditures for education and for scientific and technological development for 1970 and 1974 are given in Table 9. One can see that the overall education budget is planned to double during this period and the scientific and technological development expenditure is scheduled to increase by 150%. Interestingly, atomic minerals research is listed separately and is due for an even larger increase.

The total amount of expenditure for the scientific and technological development plan is given on p. 43-44 of the plan. It amounts to about US $ 300 million during the period. Assuming an average of US $ 40 billion for the annual GNP, the above investment amounts to roughly 0.25% of the GNP. While this is not very high, it represents only the federal government's part in the overall research and development activity.

On pp. 43 and 44 the plan also gives the channels of the funding. About 60% of the amount will be channeled through the existing organizations, such as FNDCT (Fundo Nacional Cientifico e Tecnologico), FUNTEC (Fundo de Desenvolvimento Tecnico-Cientifico) operated by BNDE (Banco Nacional de Desenvolvimento Economico), CNPq (Conselho Nacional de Pesquisas), and FUNAT (Fundo de Amparo a Tecnologia) operated by INT (Instituto Nacional de Tecnologia).

The breakdown among these organizations is not given. Table 12, however, gives the budget of CNPq between 1965 and 1969. This budget increased precipitously during that period, and hence an extrapolation to 1970 (or particularly to 1974) is risky. In any case, the 1969 budget of CNPq is about 20% of the total scientific and technological development budget for 1970.

Table 12 also shows that in 1969 about 10% of the CNPq budget was given out for research projects to some 665 projects.

Indonesia

There is no information whatever in the Indonesian plan about the funding of scientific and technological development.

Korea

Recent data on Korean investment into science and technology are given in Tables 27-34. One can see that by 1969 the percentage of GNP devoted to research and development rose to slightly over 1/2%, of which about 85% was provided by the government. Over 98% of the governmental investment was into research institutes, and only somewhat over 1% into colleges and universities. Private investment is somewhat more evenly distributed between the two channels, about 35% going into research institutes, 10% to the universities, the remainder of 55% being spent in companies. Incidentally, there are minor inconsistencies in the amounts of the various tables in the Korean data, such as, for example, the total research and development amount in Table 27 and 28. It is also interesting to observe how the share of wages in the total expenditure rises fast from year to year, hopefully a sign of increasing affluence and not of featherbedding. Expenditures are also broken down into basic research, applied research, and development. In the research institutes (which as we saw carry most of the load), the ratio of these three activities in terms of expenditure is roughly 3:4:9, thus giving a relatively prominent role to basic research with about 20% of the expenditures instead of the more usual 10%. Interestingly, even the universities and colleges do a percentagewise substantial amount of applied research and development: There the ratio of the three activities is about 40% : 33% : 28%. Private companies do mostly applied research and development, with basic research taking only about 10% of the funds. It is also interesting that the research and development expenditure per reseacher is by far the highest in the research institutes, twice as high as in private companies and ten times (!) as high as in universities and colleges. Though some similar trends also exist in the US, the disparity is not nearly as large. Also, the expenditure per researcher, between 1966 and 1971, tripled in the research institutes while it stayed constant in the private companies. The university figure is subject to huge year-to-year fluctuations. About 40-45% of the governmental funds into science and technology is dispersed through the Ministry of Science and Technology.

Concerning the plan period of 1972-76, information is summarized in Tables 35-39, again with some discrepancies among the figures in the various tables. One can see that by 1976 the total research and development share of the GNP is planned to be increased to 1.5%. The relative importance of basic research will somewhat decrease, from about 20% to about 15%, the difference going mainly toward development. The total investment for the five year period is scheduled to be about nine times the investment in 1971, with private industry assuming a rising fraction of the total. (Again, there appears to be a discrepancy between Tables 27 and 38 concerning the fraction of the expenditures between government and private industry).

Very long-range data are also available for Korea, indicating that the projected expenditure for the five year period between 1982 and 1986 will be almost five times that for the comparable period of 1972-76. By then, the research and development expenditure will constitute 2.5% of the GNP, thus roughly matching the present figures for the most advanced countries of the world.

Nigeria

Nigeria's expenditure on research and development is quite high. As Table 42 indicates, for 1966-67 the total expenditure, as far as it was known, was about \$ 30 million, which at that time was 0.7% of the GNP. More recent information as given in GOWON (1972), pp. 56 and 57, indicate that the total is now about 1% of the GNP, namely about \$ 50 million.

The plan does not contain direct quantitative information about the total research and development expenditures projected for the plan period. Some data are given pertaining to technical and university education in NIGERIA (1970), p. 239, but it is not possible to separate strict educational costs from research costs in those figures. On p. 315, figures are given for the cost of education for primary, secondary, and university students, which are startling: $ 18, 225, and 3,000, respectively.

Turkey

Turkey's expenditure for research and development has been relatively low. As Table 52 shows, the total in 1964 was about $25 million, which at that time was 0.37% of the GNP (See CELASUN (1972), p. 18). According to the plan (TURKEY (1969), p. 220), during the plan period this amount is to be increased to 0.6%. If one interprets the data in Table 52 as meaning basic research by the higher education sector and applied research and development by the public sector and the private sector, one arrives at a figure of 12% of the total research and development going for basic research, but this interpretation might be unwarranted.

CELASUN (1972) gives further data. It estimates that even in 1969 the research and development expenditure was the same 0.35% of the GNP. Furthermore, it is pointed out, some of these funds go toward surveying work which should not be counted as research and development. Most of university research consists of small projects, so that in 1964 the average amount of research expenditure per research scientist in the university sector was about $1,000 per year.

The plan calls for special effort in research and development, particularly in industrial areas for which a special sum of $40 million is appropriated for the plan period.

Though TUBITAK (Turkish Scientific and Technological Research Council) plays a very prominent part in Turkish scientific and technological planning, its budget (see Table

53) is only a few percent of the total research and development expenditure. The actual dispensing of research funds is shown for 1964 in Table 54. One sees that funding is extremely multichanneled, though about 1/3 of the funds are spent through the Ministry of Agriculture.

D. Supporting Services

The discussion of services supporting scientific and technolcgical activities, such as information systems, shops, stockrooms, etc. generally does not occupy a prominent place in development plans. There are, nevertheless, some references to such problems.

Brazil

There has been for some years in Brazil an organization dealing with scientific and technological information and documentation. It is the Instituto Brasileiro de Bibliografia e Documentacao, or IBBD, which is under the CNPq. Its function is briefly described in UNESCO (1969b), p. 86. At that time it had 37 librarians and 5 documentationists. Its scope and effectiveness has been limited, however, as explained in NAS (1968b), p. 15 and pp. 30 and 31. Here various remedies are also suggested in terms of modernization, better coordination, and coverage of more applied areas. Interestingly, it is also suggested that the law permitting only graduates of library schools to be engaged in information and documentation services be abolished. The same report also urges the improvement in the collection of international journals, the creation of more Brazilian journals, and the expanded training of librarians. In 1968 Brazil had only 6,000 graduate librarians, but 13,000 libraries in operation (which is probably the motivation for the above mentioned suggestion to change the law).

Correspondingly, the plan (p. 55) proposes the creation of a national system of Scientific and Technological Information, including science, technology, patents, agriculture and information from abroad.

Indonesia

The Indonesian plan (Volume 2c, pp. 131 ff) deals relatively extensively with information problems, pointing out the decline in publications due to printing costs, the inadequate distribution of whatever information there is, and necessity of international contacts through conferences, etc. The discussion is, however, mainly diagnostic, and nothing is said specifically about the remedies proposed under the plan.

As seen from Table 13, LIPI has a Bureau of Scientific Publication, which presumably is responsible, among other things, for the publication of the periodicals published by LIPI which are listed in INDONESIA (1971), p. 4 and 5 as Berita LIPI, Indonesian Abstracts, Reinwardtie, Treubia, Annales Bogoriensis, Warta LEKNAS, and Index of Indonesian Learned Periodicals. LIPI also runs a Documentation Center (also listed in Table 13).

The plan also discusses, on p. 133, some of the shortcomings of scientific instrumentation and the repair thereof. The discussion is again only diagnostic.

Korea

There appears to be no discussion of auxiliary services in the Korean plan.

Nigeria

Similarly, there appears to be no discussion of auxiliary services in the Nigerian plan either.

Turkey

The Turkish plan, on p. 221, specifically calls for the establishment of a Scientific and Technical Documentation Centre with the usual type of responsibilities.

E. Organization and Management

Overall information on policy making bodies in the countries under consideration is given in Table 8.

Brazil

Brazil certainly abounds with organizations in the development area, as well as in the scientific-technological fields. In the latter, the overall coordinating body is CNPq (Conselho Nacional de Pesquisas), which has under it a number of research organizations, enumerated (as of 1968) in UNESCO (1969b), p. 85-89. They are: Instituto Nacional de Pesquisas da Amazonia (INPA), Museu Paraense "Emilio Goeldi", Insituto Brasileiro de Bibliografia e Documentacao (IBBD), Instituto de Matematica Pura e Aplicada (IMPA), Instituto de Pesquisas Rodoviarias (IPR), Grupo de organizacao da Comissao Nacional de atividades espaciais (GOCNAE), Coordenacao do aperfeicoamento do pessoal de nivel superior (CAPES), Conselhos de Pesquisas das Universidades Federais, Conselhode Pesquisas da Universidade Federal do Rio de Janeiro, Fundacoes de Amparo a Pesquisa, Comissao Nacional de Energia Nuclear (CNEN), Fundo de desenvolvimento tecnico-cientifico do Banco Nacional de Desenvolvimento Economico (FUNTEC-BNDE), Superintendencia do Desenvolvimento do Nordeste (SUDENE), and Superintendencia do Desenvolvimento da Amazonia (SUDAM). The scientific and technological component of the overall plan is called Plano Basico de Desenvolvimento Cientifico e Tecnologico (PBDCT) which is funded by FUNTEC-BNDE (see above), and managed by CNPq and the Instituto Nacional de Tecnologia (INT), the latter having the Fundo de Amparo a Tecnologia

(FUNAT). As far as the plan is concerned, CNPq is to work in cooperation with the Ministry of Planning and General Coordination. In reassessing research policy, these two organizations are to be joined by the Departamento de Administracao do Pessoal Civil (DASP).

Indonesia

In Indonesia the overall coordinating body in science and technology is the Indonesian Institute of Science (Lembaga Ilmu Pengetahuan Indonesia, LIPI). Originally, in 1962, two bodies were created to manage research: The Ministry for National Research and an autonomous body called MIPI (Madjelis Ilmu Pengatahuan Indonesia = Indonesian Council of Sciences). In 1966 the above ministry turned into LEMRENAS (Institute for National Research). Finally, in 1967, LIPI was created, replacing all these previous organizations (INDONESIA (1971), p. 1).

LIPI is supposed to promote science and technology, foster research, make preparations for an Indonesian Academy of Sciences, advise the government, the research institutes, and researchers, spread general awareness of science, and maintain international connections. Its organizational structure is shown in Table 13.

Administratively, however, some of the research is not under LIPI's management but under ministerial departments (See INDONESIA (1969), Vol. 2c, p. 128-129). This ministry-managed research is generally more mission oriented. Beside these and the LIPI-managed research institutes, research is also carried out at the universities. The plan gives no details on the relative sizes of these three sectors.

Korea

In Korea the overall direction of scientific and technological activities are under the Ministry of Science and

Technology (MOST). This Ministry is, however, advised in policy matters by a Policy Committee of Science and Technology. There is also a Manpower Development Committee, which is an interministerial body involving a number of governmental agencies. Development financing in science and technology is done through a Science and Technology Fund, managed by the Ministry of Science and Technology. The budget of MOST is given in Table 34. Comparing it with Table 28 we see that MOST has under its jurisdiction approximately half of the funds spent on research and development in Korea.

A detailed discussion of the structure of MOST is given in KOREA (1972b). Beside many administrative sections, MOST has six committees with policy forming and advisory roles. These pertain to the general development of science and technology, to manpower development, to atomic energy, to research and development project review, to science and technology fund operation, and to professional engineers' management.

Nigeria

The history of science and technology management in Nigeria is an interesting and unusual one. Feeling the need for the establishment of a machinery to organize and manage science, and having been urged to do so for a number of years by prominent Nigerian scientists, the government of Nigeria approached UNESCO in the mid-1960's to give expert help in the formulation of such a machinery. The UNESCO mission came to Nigeria in 1966 (for a detailed account of this history, see MARTIN (1970)), and after thorough consultation with the representatives of the Nigerian scientific and technological organizations, it recommended a procedure to set up such a machinery. According to this recommendation, the Nigerian Council for Scientific and Industrial Research (NCSIR) became the overall national science policy body. In 1969-70 this organization turned into The Nigerian Council for Science and Technology (NCST). This council is assisted by four more specialized bodies, namely the Agricultural Research Council of Nigeria (ARCN), the Industrial Research Council of Nigeria (IRCN), the Medical Research Council of Nigeria (MRCN), and the Natural Sciences Research Council of Nigeria (NSRCN). The membership of NCST includes ministerial representatives, officials of state governments, and representatives of scientific disciplines, roughly in equal numbers. It appears from GOWON (1972) that the relationship between NCST and the highest levels of the Nigerian government is very close and cordial. The council, actually placed into operation in 1970, has so far mainly dealt with organizing itself and defining its goals (NIGERIA (1970b)). Apparently the <u>de facto</u> work done by the council is carried out by its steering committee of eight members (the whole council has 35 members). The steering committee consists entirely of scientists (GOWON (1972), p. 59).

There are indications that NCST will set up procedures to exempt scientists from the regulations and organizational constraints of the regular civil service system (GOWON (1972), p. 63). This can have very far reaching beneficial effects on Nigerian science, as it is evident from discussions like that of SABATO (1970).

<u>Turkey</u>

Universities in Turkey are divided into those with autonomous status and those under the Ministry of Education (UNESCO (1967, p. 85). In some cases universities were established with regional development in mind (OKYAR (1968a)).

Development planning in Turkey is the duty of the State Planning Organization (SPO). The financing of development, however, is a split responsibility between the SPO and the Ministry of Finance. In addition, the educational institutions, which in 1964 spent about 12% of the total research and development budget, have much autonomy in deciding the directions of their research (CELASUN (1972). In addition, the Turkish Scientific and Technical Research Council was formed in 1963 (TUBITAK), with a mission of overall science policy planning and advice. TUBITAK, however, directly controls only a very small fraction of research and development funds, as was pointed out in my earlier discussion of funding. TUBITAK recently established a TUBITAK Research Institute in the area of industrial research and development. The primary effort to develop science and technology is therefore carried out jointly by SPO and TUBITAK. The loose organization of the university research was criticized in OECD (1969), p. 234, as being harmful to efforts toward a better coordination of Turkish activities in science and technology.

The plan discusses organizational questions on pp. 220-222, and recommends the establishment of a Scientific and Technical Research Organization, an Economic and Social Research Organization, as well as the Scientific and Technical Documentation Centre already mentioned. A broad spectrum of missions for these organizations is outlined in general terms.

F. Utilization of Science and Technology

It is very important that the indigenous efforts in science and technology have a smooth interface with industrial and other economic efforts. This problem receives some attention in development plans, though generally not in sufficient amounts.

Brazil

The Brazilian plan touches upon this problem on pp. 54, 57 and 58, and suggests integration centers for university-industry relations, a closer coordination of government research institutes with productive enterprizes, the granting of government contracts to universities for applied research, and for extending student participation programs in development.

More detailed discussion of this aspect of Brazilian development is given in NAS (1968b) essentially along the same lines. Various specific shortcomings are pointed out, such as low salaries, information gaps, very little in-house industrial research, overbureaucratization, etc.

Indonesia

Only a few general sentences are devoted to this problem in the Indonesian plan, Vol. 2c, p. 134.

Korea

A report on this problem in the Korean context has been presented by the director of the Korean Consultant Group (BYUNG (1972)). It deals specifically with industry-academia collaboration. It lists steps already taken to remedy the problem, such as UN-helped projects to improve management of small and medium industries, seminars for academic faculties concerning industrial activities, joint acitivities between universities and industry toward mutual understanding, the establishment of KIST (Korean Institute of Science and Technology) with a specific mission of integrating science, technology and industry, and consultantships by academic personnel in industrial organizations.

Steps for the future are also suggested. They include more in-house research in Korean industry, the de-emphasis of imported technology, a greater participation of the academic community in science and technology transfer processes, that is, in the survey of the world science for items of possible use in Korean industry, and a greater attention paid to the managerial capabilities of those in the productive areas of science and technology.

Nigeria

According to UNESCO (1966), p. 66, some of the governmental departments in Nigeria have had for some time the tradition of combining basic with applied research. In GOWON (1972), p. 59-60, special point is made of the attempts to develop a gari machine (i.e., a machine to process cassava root). This project is directly under the NCST.

The plan itself also lists several specific programs to enhance the interaction between science and technology on the one hand, and industrial production on the other. On p. 150-151, among other development projects, the plan calls for the strengthening of the Federal Institute of Industrial Research which plays a part in the transfer of industrial technology. Also strengthened will be the Standards Organization, which provides industrial standards.

Turkey

It is evident from the plan as well as other sources that in Turkey there is a serious lack of connection between the industrial sector and the scientific and technological community. CELASUN (o972) discusses this in some detail on pp. 27-29. The main organization to bridge this gap is planned to be the TUBITAK Research Institue, already mentioned previously. It is also suggested, however, that tax incentives and other methods be employed to generate more and more subtle transfer of technology from abroad.

G. International Connections

One of the potentially very fruitful forms of international connections in science and technology is the formation of bilateral links between institutions, departments or groups of researchers, one in a more advanced country and another in a less developed one. LOMAN (1969) offers a statistical study of such bilateral links for a very large number of countries. The relevant information from it pertaining to the five countries under consideration is given in Table 55. It must be emphasized that the very valuable study by Loman is by no means complete. In addition, it simply counts bilateral links, regardless of their size, and provides no information on the extent to which they are actually functioning. Nevertheless, taking the information in that study at face value, one obtains the interesting picture of Brazil and Nigeria abounding in such links, Turkey having half that many, and Indonesia and Korea having hardly any. The distribution among various disciplines varies from country to country considerably. As to the "donor" countries, the US and West Germany carry equally between them about 3/4 of all links.

In addition to this type of international connections, some comments are in order about the various individual countries. As already mentioned, Brazil has a very extensive chemistry program which is managed and financed in cooperation with the US, through the US National Academy of Sciences. As to Indonesia, Table 13 lists some international organizations LIPI is a member of. In Korea's case KIST is a product of an international cooperation between Korea and the US, involving millions of dollars just as the Brazilian project does. As NAL (1969) shows on p. 6, the investment of US AID into KIST was almost $4 million in 1967 and almost $3 million in 1968. The establishment of KAIS (Korean Advanced Institute of Science) was also an instance of international collaboration, as is evident from US AID (1970). In KOREA (1972c), pp. 10 and 11, some data are given about the amount of technical assistance received by Korea. It is between about $9 million and $21 million a year during the period of 1966, with a peak in 1968 and a gradual decrease since then. Also given is the technical assistance donated by Korea, in terms of the number of people sent abroad. It has been increasing unceasingly and fast, from 30 people in 1966 to 194 people in 1971. Most of these people go to other Asian countries, with about 10-15% distributed to other parts of the world.

Nigeria offers no additional information on international connections in its plan or the supplemental material. One should recall, however, that, as discussed earlier, the setting up of the science policy mechanizm in Nigeria was itself a product of international connections.

In the Turkish plan a separate though short section (pp. 223-226) is devoted to international scientific and technical cooperation. It deals with the knowledge of foreign languages by scientific and technical personnel, with the utilization of Turkish manpower trained abroad, with the participation in international cooperative projects, and with a better utilization of the scientific and technical components of foreign aid projects in which Turkey is the recipient.

H. Output

As remarked earlier, the discussion of scientific and technological output in development plans is practically completely absent. This statement might at first sight be contradicted by various targets and extrapolations in the plans concerning the scientific and technological manpower to be created by the end of the plan. In fact, however, there is no contradiction there. The output of science is not scientists, and the output of technology is not technologists. Science viewed as an activity aimed at producing more scientists becomes an empty game, and the same is true for the corresponding situation in technology.

Instead, the purpose of science is to produce scientific knowledge, and the purpose of technology is to produce technological inventions. Thus in measuring the output these are the factors we should concentrate on. The measurement of these, however, is a very difficult matter, as I discussed earlier in this study, and there are no generally accepted reliable methods to do so.

I will, therefore, use two indicators of output which, though not without shortcomings, do give some indication of scientific and technological output.

The first of these is the number of first authors in Current Contents of 1967, as tabulated in PRICE (1969). Current Contents covers about 80-90% of the scientific literature. The main disadvantage of this index, from a purely mechanical point of view, is that it pertains only to first authors of scientific publications, and hence one loses many authors whose names never happen to be the first among a group of authors. Since the list of authors in scientific papers are often arranged in alphabetical order, picking first authors might very well have serious geographical biases. In addition, of course, there are many more organic objections to this measure, though this is not the place to discuss those at length. But for whatever its reliability might be worth, information is readily available in terms of this index.

The information pertaining to our five countries is shown in Table 56. I also indicated there the number of authors per million population. In terms of that index, the ranking of the countries is as follows: Brazil, Nigeria, and Turkey, in this order, with rather large figures, Korea with about a third as large a figure, and finally Indonesia with less than one tenth of that figure.

PRICE (1969) relates the number-of-authors-index to the GNP. On such a plot one finds a roughly linear relationship, with about 10 authors for every billion dollars of GNP. There are, however, deviations from this relationship amounting to a factor of ten in each direction for very low GNP countries, and perhaps a factor of five in each direction for countries with a GNP of the order of magnitude of 10 billion dollars, which is where all of our countries lie. Actually, all five countries lie somewhat low on such a plot as compared to the average, that is, all five countries appear to produce fewer authors than, on the average, their GNP would warrant. The least favorable position is occupied by Indonesia, which in fact is conspicuously outside the overall scatter of countries on such a plot (See PRICE (1969), p. 109-110).

The other measure I will use is patent statistics which should be an indicator of technological activity. Unfortunately, of the five countries, only Korea offers such information among the material at my disposal. This information is shown in Table 57. One can see from it that the number of patents in Korea has been steadily increasing, though when utilities, designs, and trade marks are also counted, there appears to be a plateau reached between 1968 and 1971. It is also evident that most of these patents are by Koreans and not foreigners, and that the research expenditure per invention for Korea is quite low in international comparison, which is presumably a good sign. It might be mentioned that the number of patents' applications in the US during the time period covered in the Korean statistics is about 90,000 per year.

IV. CONCLUSIONS

In this section I will try to draw some conclusions from the material in the previous sections. I would like to emphasize again, however, that these conclusions are drawn mainly on the basis of the material available to me during the preparation of this study, and as such might not be complete.

This section will consist of the following parts. First, I will give a comparative summary of some of the information derived from the study of the national development plans. Following this, I will list those important elements of the scientific and technological life of a country which cannot be learned from a study of development plans. This will lead to some comments on how one can devise other channels through which these additional elements can to some extent be ascertained. Since these channels utilize scientists, this discussion is naturally followed by a general emphasis of the participation of scientists and technologists not only in the assessment of science policy but also in the formulation of the science and technology components of national development plans.

The previous sections do give a definite picture of the efforts of all five countries to channel resources into the development of their science and technology. The extent of this effort, however, emerges as quite different from country to country.

The most extensive and thorough planning appears to be that of Korea. Its plan is detailed, ambitious, and based on short as well as long term projections.

One of the evident problems in Korea appears to be the relative neglect of the universities in comparison to research institutes. The recent establishment of KAIS might begin to remedy this problem, but more attention appears to be called for in this direction.

On the other hand, Korea appears to have done quite well in establishing a fairly functional link between science and technology on the one hand, and industrial activities on the other.

Korea faces a short term scientific and technological manpower surplus in a quantitative sense, and there is no indication that this surplus problem is dealt with in a realistic way, perhaps because the long term projections into the 80's predict a disappearance of this surplus.

Korea's financial investment into science and technology is at the moment only moderate in terms of the percentage of the GNP, but its plans to expand this investment are impressive.

One has the feeling that the organizational structure of Korea's science and technology is a bit overly centralized, MOST having no significant single competitor. Whether this is a real danger or not would have to be evaluated on the basis of a thorough on-the-spot but informal investigation of the de facto decision making and of the personalities involved.

Korea's international connections in science and technology appear to need some expansion.

Perhaps the second most extensive planning effort is that of Turkey, though the past performance of Turkey in the development of science and technology is by no means as impressive as that of Korea. Conservatism in the university system, and a lack of connection between the academia and the industrial-technological segment of the community appear to be two major problems. Turkey faces a shortage of scientific and technological manpower, and yet the brain drain appears to be, even quantitatively, a significant problem. The financial resources devoted to science and technology are relatively low and even the projected amounts stated in the plan are not really impressive. In contrast to the potentially overcentralized situation in Korea, Turkey might suffer from too little coordination. TUBİTAK has played a beneficial role, but progress has been slow.

Though the Brazilian plan itself is a bit skimpy in its discussion of science and technology, supplementary material appears to indicate a considerable expansion. Manpower development is emphasized, and the brain drain does not appear to be serious, at least quantitatively. The financial investment into science and technology is moderate at the present in terms of the percentage of GNP, but large future increases are planned. The Brazilian plan is the only one of the five with a somewhat more than nominal mention of the importance of supporting services, with particular attention paid to information systems.

The organizational structure of science and technology development in Brazil includes many organizations and on the face of it appears to be well balanced.

There is relatively little information in the plan on the interfacing with industry, but that, together with auxiliary information, appears to indicate the need for considerable improvement.

The previous three countries, Korea, Turkey, and Brazil, are definitely in a somewhat advanced state of development compared to the remaining two, Nigeria and Indonesia. This is reflected in the present size of scientific and technological manpower, in the present per capita GNP, as well as many other indicators. As a result, their problems are also different. The more advanced three countries are concerned with the further development of manpower, with the expansion of scientific organizations (and in some cases with the reforming of already existing and obsolescent organizations), etc. In sharp contrast, the other two countries, Nigeria and Indonesia, are in the very beginning stages of development, concerned with the establishment of scientific institutions and manpower, the creation of an organizational structure, and the planning for an effective interface between scientists-to-be and industry-to-be. In doing so, they are in the position of taking advantage of the enviable and rare opportunity of being able to start something from scratch without having to live with previous mistakes.

Of the two countries, Nigeria appears to have responded to this challenge more readily. Its manpower development plans appear to be intensive, with no excesses on the horizon. Its expenditure on science and technology is exemplarily large, and its organizational structure, conceived in an unusually methodical way, appears to have an unusually well developed network of international connections in science and technology.

In contrast, Indonesia appears to be still in the process of formulating its ideas as to what to do about the development of science and technology. The Indonesian plan is unusually void of quantitative information on past performance and future plans for science and technology. There is some purely descriptive and exhortative discussion on some of these matters, including even some supporting services, but it is difficult to obtain a definite picture of exactly what is expected to happen in these respects during the plan period. Financial figures are also missing. As far as organizations are concerned, LIPI exists but is just beginning to devote itself to policy questions.

As far as output indicators are concerned, the material behind this study was very skimpy. The scientific author count showed that within its own uncertainties and shortcomings all countries considered are comparable with the world average for those particular GNP's, though perhaps there is a slight systematic deficiency in authorship for the whole group compared to the world average. Indonesia appears to be the lowest on the scale, and its deviation from the "norm" is large enough so as to possibly indicate a real degree of retardation in "scientific size" compared to "economic size". The patent indicator is available only for Korea, but it appears to be quite favorable for that country.

Having outlined some of the conclusions one can draw from a study of the development plans and from auxiliary material, I will now discuss what we <u>cannot</u> learn from such material, recalling some of the general points made in Section II concerning the methodology of science evaluation.

Regrettably, one must say in all honesty that some of the most crucial and relevant aspects of science and technology development in the countries under consideration <u>can not</u> be ascertained from development plans or other written material. A few examples will suffice. Plans do not discuss the <u>quality</u> of manpower that has been trained or is planned. Plans do not tell whether a given research institution is a nominal organization with no significant scientific or technological productivity, or whether it is a florishing and vital center which is making great progress in solving problems. Plans cannot tell whether a certain national research council is an honorary collection of venerable have-been's or a creative group of active and motivated people ready to catalyze and support activity in science and technology. Plans or other auxiliary material cannot tell whether a scientific publication or author is just marginal or truly first class. Patent counts do not take into account the potential impact and importance of inventions which might vary tremendously from patent to patent.

All in all, the two main shortcomings mentioned in Section II are very much in evidence: The difficulty of measuring quality as opposed to quantity, and the distinction between mere activity on the one hand, and productivity and progress on the other. The article by Sabato (SABATO (1970)) already referred to is one of the most eloquent and perceptive analyses of this point, giving specific examples which might very well apply to some of the countries in this study.

As mentioned earlier, at the present time, to the best of my knowledge, there is only one method, however imperfect, known to us that can generate some information along these missing dimensions. It is a consensus of personal views of a sufficiently large number of competent scientists and technologists from the international community, who have been given a sufficiently extensive opportunity for personal contact with the countries under investigation so as to be able to form a fairly reliable opinion.

At the present time it would indeed be difficult to establish such a consensus for several reasons. First, there are simply not enough scientists within the international scientific community who have a sufficiently thorough acquaintence with the scientific achievements of a given country in the various areas of the sciences so as to form a reliable sample for a consensus. It is clear that we must have increased opportunities for individual scientists and technologists to spend some time in some of the less developed countries. Coupled with this, we must also have a sufficient number of scientists and technologists who are willing to undertake such extended visits. This in turn requires an increased awareness within the scientific and technological community that the scientific and technological development is a crucial component in the emergence of the less advanced countries, and that personal involvement by many individuals in the worldwide scientific and technological community is absolutely needed to speed up such a development.

Second, even in the absence of any extensive body of external knowledge of the scientific development of a country, much more could be obtained from the amount of knowledge that does exist. For example, to the best of my knowledge no attempt has ever been made to conduct a census of the expertise available within the American scientific community in terms of personal contacts with and stay in less developed countries, let alone trying to exploit this manpower by taking an actual consensus of views. Most likely the same is true for the scientific communities of other advanced countries.

I believe that without the extensive (though not necessarily expensive) use of direct, scientific and personal contacts with the less developed countries, we will continue to be reduced to the scholarly evaluations of formal documents about science planning and science activity, for which the present study is an example. While such evaluations have some utility, they fall far short of the mark in terms of what is really needed to make an organic and realistic assessment of the degree of success less developed countries are making in their building of their science and technology. In as much as a competent, organic, and unbiased evaluation and critique is one of the most valuable contributions we can make to these countries, the problem of improving such evaluations should receive top priority.

As to the organizational form such a professional evaluation can assume, some precedent is available from some of the OECD activities. This organization prepares critical assessments of some of its member countries in terms of scientific, technological, and economic development, which are generally judged quite helpful. To be sure, one has to have the proper organization for such a task: Some of the superinternational organizations, like UNESCO or IAEA, might not have the political leeway to engage in such substantive activities. Regional organizations or even bilateral links between countries might be able to serve better as vehicles for such evaluations. If these assessments acquire the reputation of objectivity, discretion, and professionalism, and if they could be also extended to the scientifically more advanced countries, then they could be made generally acceptable without the countries to be assessed feeling that they are washing dirty linen in public.

Evaluations, however, would not have to be carried out by formally organized teams. The collection of views of individual scientists would constitute a similarly valuable, and perhaps even lower-keyed way to achieve such an assessment. This is why the strengthened channels, mentioned above, for visits by individual scientists are important.

So far I have emphasized the need for an increased involvement by scientists in the more advanced countries. There is, however, a similar need for the increased involvement of scientists and technologists in the less developed countries themselves. It is quite evident from the above outline of national development plans that in a number of the countries surveyed there was a complete lack of participation by the indigenous scientific community in the national planning process, and in fact none of the development plans studied gave the impression of having been contributed to by the whole national pool of scientific manpower. As a result, there were omissions of presumably important elements in these plans, and they also contained some formal and unrealistic elements which could have been remedied by direct involvement of scientists. It is in fact generally the philosophy both in less developed and in advanced countries that development planning is a job for economists, perhaps with a light sprinkling of casual contact with other professions. One gets this impression not only from reading development plans, but also from surveying the activities of some international development agencies such as US AID.

But planning development is no more an exclusive domain of economists than the creation of new laws is the sole responsibility of lawyers. What a lawyer can and should do is to take the substance of a new law agreed upon the basis of studies and testimony by professional experts, of practical assessments by law enforcing agencies, and of social evaluations by various segments of society, and then give this substance a legal framework so that it can be used as a law in the technical sense of the word.

Similarly, what an economist can and should do is to assemble the plans and aspirations of the many groups in a country that have something to contribute in the way of development, and then coagulate these elements into an economic framework so it can be used as a course of action by the government. To be sure, the analogy is somewhat limping, since in this case economics itself is one of the important ingredients, and in that area of course economists must have their professional say. But in other areas, the active participation of professionals from various fields must be greatly enhanced in order to produce a realistic, creative, and productive plan.

Specifically, the science and technology component of a development plan must be the primary concern of scientists and technologists until the very final stages when the whole plan is coordinated, and even then, they must be represented to assure that some of the superficially expandable but organically crucial elements are not sacrificed. Similar active participation on the part of scientists and technologists is needed to evaluate the performance of past development plans.

Such a truly interdisciplinary approach will not be easy to achieve. Social scientists and economists will continue to question the relevance and effectiveness of bringing in such outside "expert" collaboration, and those in the natural sciences will not readily engage in such "non-scientific" activities as mingling with the "fuzzy-brained other culture". Yet, unless we just want to amuse ourselves by setting up hypothetical development schemes with no functional and realistic productive capacity, we must reach out in the direction of this much better integrated, multidisciplinary approach to development planning.

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USAID (1970)	US AID Survey Report on the Establishment of the Korean Advanced Institute of Science 1970
USAID (1972)	US AID Economic Data Books (unpublished) 1972
WON (1972)	Won Ki Kwon Skilled Manpower Planning in Korea Report, 1972

TABLE 1. GENERAL STATISTICS

		Brazil	Indonesia	S. Korea	Nigeria	Turkey
Area (US without Alaska = 1.0)		1.07	0.24	0.012	0.12	0.10
Population: Midyear Estimate $\$10^6$	1963	76.2[a]	100.0	26.9[a]	55.3[a]	29.6[a]
	1967	85.7[a]	110.1[a]	29.8[a]	61.5[a]	32.7[a]
	1968	----	-----	----	52.4	34.4[a]
	1969	90.8[a]	116.0[a]	31.1	64.6[a]	----
		92.6	116.6		53.7	
	1970	95.2	119.6	----	55.1	35.2
	1971	98.0	122.7	32.5	56.5	36.2
	1972	100.8	125.9	33.2	58.0	37.1
% of Population in Labor Force	1950	33	-----	----	----	----
	1955		-----	----	----	50.4
	1960	32	-----	30.4	---	47.2
	1963	--	-----	----	32.9	----
	1965	--	-----	32.4	----	43.7
	1970	32	-----	31.5	----	----
Literacy Rate %		1970: 67% of 15 yrs+	1961: 43% of 15 yrs+	71%	25%	(1960: 40%) 46%
Life Expectancy Yrs.		63	1960: 48	1965: 58	41	57
% of Urban Population	1950	36	-----	----	14	19
	1955	--	-----	23	----	----
	1960	46	-----	28	18	26
	1970	56	-----	----	23	35
	1971	--	-----	39	----	----
GNP 1970 \$ $\$10^9$	1968	29.0	-----	6.51	----	8.07
	1969	31.6	-----	7.54	----	8.57
	1970	34.6	12.6	8.21	5.8	9.04
	1971	38.5	-----	9.05	----	9.87
Per Capita GNP 1970 \$	1968	322	-----	219	----	241
	1969	341	-----	242	----	249
	1970	364	105	258	105	257
	1971	394	-----	278	----	273

TABLE 1. GENERAL STATISTICS (con't)

		Brazil	Indonesia	S. Korea	Nigeria	Turkey
Distribut./	Year	1967	1970	1970	1969	1970
of Domestic/	Agr.	19	48	28	53	31
Product/ % /	Mfg.	26	13	21	10	20
	Constr.			6	5	7
Transp.& Commun.		6	--	8	4	7
Trade & Finance		22	18	19	13	10
	Other	26	21	17	15	25
Per Capita	1960	320	19	71	12	100
Electricity	1968	420	18	210	21	210
Production	1969	450	19	260	23	230
KWH	1970	480	--	300	25	250
	1971	500	--	---	32	270
% of National Income Spent on Education, 1968		1.0[a]	0.7[a]	2.4[a]	2.5[a]	3.5[a]

Figures with the superscript a are from U.S. (1969-71). The remaining figures are from USAID (1972).

TABLE 2. EDUCATION AT THE THIRD LEVEL: Distribution of Students Graduating in the Fields of Science and Technology and Total Graduates in the Years Indicated.

		All Grads.		Graduates in Science & Tech.						
	Year	Total	Women	Total	Women	Nat. Sci.	Eng.	Med. Sci.	Agr.	Soc. Sci.
Brazil	NO DATA									
Indo-nesia	1950-1967	21832[a]	----	11050[a]	----	----	----	----	----	----
South Korea	1959	15086	1293	8824	668	1207	1185	1198	1519	3715
	1960	16837	1976	9819	792	1246	1030	1775	1371	4397
	1961	19141	NA	11606	NA	1394	1522	2251	865	5574
	1963	39697	6934	24285	2765	2365	4889	3126	2871	11034
	1964	44454	9402	27778	3803	3150	5940	3299	3538	11851
Niger-ia	1961	438	38	203	7	77	23	35	21	47
	1962	571	45	299	6	89	33	39	25	113
	1963	864	82	421	15	117	34	50	36	184
	1964	1212	125	639	36	150	36	45	85	323
	1965	1546	112	828	33	101	76	66	80	425
Turkey	NO DATA									

Legend: a = from Indonesia (1969), Vol. 2C, p. 129.

Unsuperscripted figures from UNESCO (1970).

TABLE 3. MANPOWER

Scientific and technical manpower by sector of employment, latest year available.

	Year	Category	Total	Sector of Employment: Gov't Act.	Inst. of H. Educ.	Prod. Enterp.	Other
Brazil	NO DATA						
Indonesia	NO DATA						
S. Korea	1966	SE	88,300*	18,200	3,600	39,500*	27,000
		T	111,800*	18,100	0	93,700*	0
		T/SE	1.3*	1.0	0	2.4*	0
Nigeria	1966	SE	3,970	NA	NA	NA	NA
		T	6,997*				
		T/SE	1.8*				
Turkey	1964	SE	4,500[a]	1,720[a]	2,787[a]	50[a]	

NA Not available
SE Scientists and engineers
T Technicians
T/SE Number of technicians per scientist and engineer
a From OECD (1969), p. 199
Unlabeled From UNESCO (1970b)
* Provisional or estimated

TABLE 4. MANPOWER

Scientific and technical manpower by field or specialization, latest year available.

	Year	Level	Total	Field or Specialization: Nat. Sci.	Eng. & Tech.	Med. Sci.	Agr.	Soc. Sci.
Brazil		NO DATA						
Indonesia		NO DATA						
S. Korea	1965	SE	88,300*	← 41,700* →		31,100	15,500*	NA
		SE(W)	NA	NA	NA	NA	NA	NA
		T	111,800*	NA	NA	NA	NA	NA
		T(W)	NA	NA	NA	NA	NA	NA
		T/SE	1.3*	NA	NA	NA	NA	NA
Nigeria	1966	SE	3,970	635	1,200	1,300	435	400*
		SE(W)	NA	NA	NA	NA	NA	NA
		T	6,997*	2,363*	756*	531	3,347	NA
		T(W)	NA	NA	NA	NA	NA	NA
		T/SE	1.8*	3.7*	0.6*	0.41*	7.7*	NA
Turkey	1964	SE	4,500[a]	∼ 400[a]	∼ 1,200[a]	∼1,600[a]	∼ 1,300[a]	NA

SE Scientists and engineers
SE(W) Scientists and engineers of which women
T Technicians
T(W) Technicians of which women
T/SE Number of technicians per scientist and engineer
* Estimated or preliminary
a From OECD (1969), p. 199
Unlabelled numbers from UNESCO (1970b)

TABLE 5. FUNDING

Current expenditure for research and experimental development by sector of performance.

	Currency Unit	Fis. Year	Current expenditure for R & D performed Gov't Act.	Inst. H. Edu.	Prod. Enter.	Other	Tot. Cur. Expendit.
Brazil	NO DATA						
Indonesia	NO DATA						
Korea	1000 won	1963	941,337	72,008	198,252	120,367	1,331,964
		1964	1,106,488	121,001	49,420	219,971	1,496,880
		1965	1,648,780	100,604	48,286	268,139	2,065,809
		1966	NA	NA	NA	NA	2,859,000
Nigeria	Pound	1966					9,770,000*
Turkey	Lira	1964 (?)	125 mil.[a]	24.2 mil.[a]	4.5 mil.[a]		160 mil.[a]

a = From OECD (1969), p. 199

Unlabelled numbers: From UNESCO (1970b)

TABLE 6.

Relation of scientific and technical manpower and expenditures to other elements in the national economy: Estimated number of scientists and engineers and technicians per 100,000 economically active population and current expenditure on R and D as a percentage of expenditure on gross national product at current market prices. (From UNESCO (1970b)).

Country & Year	Est. no. of Scientists & Engineers	Est. no. of Technicians	Fiscal Year Beginning	Est. Current R & D Expend. as % of GNP
1965 Korea	960	1,215	1966	0.28
1966 Nigeria	14	24		

TABLE 7. GENERAL SPECIFICATIONS AND GOALS OF THE PLANS

	Brazil	Indonesia	S. Korea	Nigeria	Turkey
Starting Date of First Plan	1972	1968	1962	1962	1962
Present Plan	1972-1974 (First)	1969/70-1973/74 (First)	1972-1976 (Third)	1970-1974 (Second)	1968-1972 (Second)
Population Targets (million)	1970: 93.2 1974: 104.1		1970: 31.3 1976: 34.3	1970: 66 1974: 73	1968: 32.8 1972: 37.4
GNP Targets $ billion	1970: 37.2 1974: 52.6		1970: 7.00 1976: 13.35	1970/71 5.80 1971/72 6.35 1972/73 6.89 1973/74 7.58	1967: 8.5 1972: 11.9
Per Capita GNP Targets $	1970: 398 1974: 504		1970: 223 1976: 339	1970/71: 88 1973/74: 102	1968: 260 1972: 320

TABLE 8. SCIENCE AND TECHNOLOGY POLICY-MAKING BODIES
From ADV COMM (1971), pp. 91-94.

Country	*Ministry for science,[a] or ministerial committee for science policy*	*Over-all science planning body*	*Multisectoral science research co-ordination body*	*Co-ordination body for medical research*	*Co-ordination body for agricultural research*	*Co-ordination body for atomic energy research*	*Co-ordination body for industrial research*
Brazil . . .			Yes[b]		Yes	Yes	Yes
Indonesia . .		Yes[bb]	Yes[bb]			Yes	
Republic of Korea . .	Yes	Yes					Yes
Nigeria . . .		Yes	Yes[bb]	Yes	Yes		Yes[bb]

Source: Based on UNESCO *World Directory of National Science Policy-Making Bodies*

[a] Having no other responsibilities.
[b] This body also performs some functions related to over-all science planning at the national level.
[bb] The same body performs both functions.

TABLE 9. SOME TARGETS FOR THE BRAZILIAN DEVELOPMENT PLAN
From Brazil (1971), p. 41.

SECTORS	Situation in 1970	1974 Goal	Increase %
EDUCATION			
● **Primary school education**			
—Enrollment n.° (thousands)	16,300	22,000	35
—Real schooling rate (*)	73%	80%	—
● **High school education**			
—Enrollment n° (thousands)	1,100	2,200	100
● **University education**			
—Enrollment n° (thousands)	430	820	90
—Faculty (full-time and exclusive dedication regime)	2,800	4,000	43
—Faculty in (other regimes)	6,000	8,000	33
● **Campaign against illiteracy:** number of illiterates between 15 and 35 years old (thousands)	8,000	2,000	−75(**)
● **Manpower training** (n° of workers trained per year)	100,000	217,000	117
● **Public expenditure in this Sector** (Cr$ million, 1972 prices)	5,500	10,550	92
● **Federal expenditure in this Sector** (Cr$ million, 1972 prices)	1,800	3,060	70
HEALTH AND SANITATION			
● Combat against endemic diseases (malaria, smalpox, yellow fever)	Local or generalized occurrence	Erradicated	
● Water supply — urban population served (thousands)	27,045	38,045	41
● Sanitary Sewers — urban population served (tousands)	13,523	19,323	43
AGRICULTURE			
● **Technological Development**			
—Fertilizer consumption (in 1,000 tons of nutrients)	900	1,400	56
—Correctives (limestone used, in 1,000 tons)	1,390	2,400	73
—Farming defensive materials (in tons)	37,000	70,000	89
—Mechanization. Farming Tractors (units)	97,000	130,000	34
● **Technical Assistance (Rural extension)**			
—Municipalities assisted	1,548	2,200	42
● **Agricultural Infra-Structure Development**			
—Northeast Irrigation Program (ha irrigated)	30,000	70,000	133
—Rural Electrification			
—lines built (km)	6,600	26,000	294
—installed capacity (millions of kW)	50	240	380
—benefitted properties (units)	117,000	420,000	259
—power consumption (in millions of kWh)	11	82	645
● **Agrarian Reform and Colonization (Transamazônica)**			
—Settled families	—	70,000	—
● **Food Market Central Units**			
—Food Market Central Units in Operation	1	15	1,400
SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT			
● Expenditures for priority projects (Basic Plan) (in Cr$ million, 1972 prices)	236	580	146
● Expenditures in atomic minerals research (in Cr$ million, 1972 prices)	15	40	167
BASIC INDUSTRIES			
● **Steel and Metallurgy (Installed Capacity)**			
—1,000 tons			
Steel	5,400	11,200	107
Aluminum	65	120	85
Zinc	18	30	62
Tin	13	15	15

TABLE 10. ENGINEERS FROM LATIN AMERICA ADMITTED TO THE UNITED STATES WITH IMMIGRANT VISAS, 1965-68
From CIMT (1970), p. 498.

Country	Total 1965	Total 1968	Civil 1965	Civil 1968	Electrical 1965	Electrical 1968	Mechanical 1965	Mechanical 1968	Other 1965	Other 1968
Total	598	933	129	137	71	129	87	134	300	533
Mexico	57	51	13	5	14	7	7	9	23	30
Cuba	119	335	34	45	13	49	29	44	43	197
Dominican Republic	16	13	2	7	1	-	2	-	11	6
Haiti	28	35	8	13	4	1	-	-	16	21
Trinidad and Tobago	8	23	4	2	-	5	1	3	3	13
Jamaica[a]	24	67	6	9	5	19	2	10	11	29
Central America	50	34	13	5	6	7	10	3	21	16
Costa Rica	10	8	1	1	2	2	4	1	3	4
El Salvador	5	6	2	1	-	2	-	-	3	1
Guatemala	7	6	2	-	-	-	1	1	4	5
Honduras	12	1	1	1	1	-	3	-	7	-
Nicaragua	5	3	3	2	1	-	1	-	5	1
Panama	8	7	4		2	3	-	1	2	3
British Honduras	4	3	1		1	-	1		1	3
South America	299	396	49	60	28	60	36	75	186	205
Argentina	88	93	12	6	5	23	10	20	61	44
Bolivia	10	7	1		-	1	4	-	5	6
Brazil	37	45	6	6	5	6	7	9	19	24
Chile	29	32	7	11	2	4	3	2	17	15
Colombia	70	110	12	20	10	15	6	14	42	61
Ecuador	13	33	4	6	2	-	1	9	6	18
Paraguay	1	-	-		-	-	-	-	1	-
Peru	17	29	3	7	2	5	3	8	9	9
Uruguay	6	4	-	2	-	-	-	4	6	-
Venezuela	24	43	4	2	2	6	2	16	16	19

[a]1966 figures; 1965 figures not available.

Source: U.S. Department of Justice, Immigration and Naturalization Service.

TABLE 11. SCIENTISTS FROM LATIN AMERICA ADMITTED TO THE UNITED STATES WITH IMMIGRANT VISAS, BY COUNTRY
From CIMT (1970), p. 494.

Country	1965	1968
Total	211	347
Mexico	34	17
Cuba	28	128
Jamaica	8	26
Other Caribbean	33	13
Central America	10	13
South America	98	119
Argentina	31	40
Bolivia	1	5
Brasil	13	13
Chile	4	4
Colombia	20	23
Ecuador	7	15
Paraguay	3	-
Peru	4	8
Uruguay	2	2
Venezuela	10	3

Source: U.S. Department of Justice, Immigration and Naturalization Service.

TABLE 12. FINANCIAL DATA FOR THE BRAZILIAN CNPq
From UNESCO (1969b), p. 91. Money in the units of NCr$.

Appropriations for CNPq

Year	Appropriation	Supplementary fund	Total
1965	6.524.343		6.524.343
1966	7.564.850		7.564.850
1967	8.762.880	6.222.000	14.985.000
1968	16.073.878	4.524.492	21.203.370
1969	49.459.000		49.459.000

Appropriations for research

Year	Number of grants	Total amount of the grants
1964	316	608.842,90
1965	441	2.057.018,11
1966	476	3.003.854,97
1967	665	4.364.964,10

Number of scholarships

Year	For domestic study	For foreign study	Total
1964	546	61	607
1965	777	76	853
1966	1.083	77	1.160
1967	1.309	95	1.404

TABLE 13. THE ORGANIZATIONAL STRUCTURE OF LIPI (Indonesian Institute of Science)

From Indonesia (1971), pp. 3-5.

The Executive Secretary is responsible for the administrative affairs and heads the administrative unit, which consists of:

1. Bureau of Coordination and Science Policy;
2. Bureau of International Relations;
3. Bureau of Public Relations;
4. Bureau of Legal Affairs and Patents;
5. Bureau of Finance;
6. Bureau of Logistics;
7. Bureau of Control;
8. Bureau of Scientific Publication;
9. Bureau of Construction;
10. Bureau of Personnel

The Deputy Chairman for Natural Sciences is responsible for:

1. The National Biological Institute;
2. The National Institute for Geology and Mining;
3. The National Institute for Oceanology;

The Deputy Chairman for Technology is responsible for:

1. The National Institute for Physics;
2. The National Institute for Chemistry;
3. The National Institute for Metallurgy;
4. The National Institute for Electrotechniques;
5. The National Institute for Instrumentation;
6. The National Scientific Documentation Centre.

The Deputy Chairman for Social Sciences and Humanities is responsible for:

1. The National Institute for Cultural Studies;
2. The National Institute for Economic and Social Studies.

The following are eleven international scientific organizations of which LIPI is a member:

1. International Council of Scientific Unions (ICSU);
2. International Union of Geodesy and Geophysics (UGGI);
3. International Geographical Union (IGU);
4. Special Committee on Oceanic Research (SCOR);
5. Committee on Space Research (COSPAR);
6. Special Committee on International Biological Programme (SCIBP);
7. International Federation for Documentation (FID);
8. Pan Indian Ocean Science Association (PIOSA);
9. Pacific Science Association (PSA);
10. International Organization for Standardization (ISO);
11. International Electrotechnical Commission (IEC).

TABLE 14. MANPOWER EMPLOYED IN KOREA, 1967
From UNESCO (1970c), p. 22.

	In government activities	In institutions of higher education[1]	In productive enterprises	In other employment[1]	Total, all employment
Professionals					
Natural sciences, engineering and technology	11 700	2 000	35 000[2]	2 000[2]	50 700[2]
Medical science[3]	4 000	1 200	600	30 200	36 000
Agricultural sciences	8 800	700	7 000[2]	—	16 500[2]
TOTAL, all professionals	24 500	3 900	42 600	32 200	103 200
Technicians					
TOTAL, all sciences	23 700	—	106 700[2]	14 600[2]	145 000[2]

1. — = nil or negligible.
2. Estimated or provisional figure.
3. Including engineers in fisheries and marine activities.

TABLE 15. KOREAN SCIENTIFIC AND TECHNICAL MANPOWER SUPPLY AND DEMAND
From WON (1972), pp. 3-5.

Scientific and Technical Manpower Demand

(Unit: 1,000)

Class. / Year	Total Employment (A)	Scientific and Technical Manpower(B)				
		Total	Scientists & Engineers	Technicians	Craftsmen	B/A (%)
1970	9,941	477.4	24.8	57.9	394.7	4.8%
1972	10,532	603.0	29.5	68.9	504.6	5.7%
1976	11,792	915.5	41.1	96.2	778.2	7.8%
Annual Average Growth Rate	2.9%	11.5%	8.8%	8.8%	12.0%	

Scientist and Engineer Supply and Demand (Unit: 1,000)

Supply & Demand / Year	Total	1972	1973	1974	1975	1976
Demand	.	29.5	32.1	34.9	37.9	41.1
Supply		32.9	36.0	39.9	42.6	45.5
Now Employed		26.3	28.6	31.2	33.9	36.8
Science & Engr. Colleges	40.1	6.6	7.4	8.7	8.7	8.7
Balance	21.4	3.4	3.9	5.0	4.7	4.4

TABLE 15. KOREAN SCIENTIFIC AND TECHNICAL MANPOWER SUPPLY AND DEMAND (cont.)

Technician Supply and Demand (Unit: 1,000)

Supply & Demand / Year	Total	1972	1973	1974	1975	1976
Demand		68.9	75.2	81.7	88.7	96.2
Supply		68.9	75.2	81.7	88.7	96.2
Now Employed		61.4	66.9	73.0	79.3	86.0
Junior Colleges	18.5	4.4	3.2	3.3	3.8	3.8
(Expansion of Technical Junior Colleges)	(7.8)	(-)	(0.9)	(1.8)	(2.3)	(2.8)
(Vocational Training)	(3.4)	(0.1)	(0.4)	(0.7)	(1.1)	(1.1)
(Surplus from Colleges and Univ.)	(14.4)	(3.0)	(3.8)	(2.9)	(2.2)	(2.5)

Note: Figures in parentheses represent the additional supply plan.

TABLE 16. DEMAND AND SUPPLY FOR KOREAN TECHNICAL MANPOWER
From Korea (1971a), p. 84

In thousand person

	1970	1976	1972-1976 [1]
Total Demand	477	915	376
Total Supply	471	930	397
Balance	-6	15	21
Scientists and Engineers			
Demand	25	41	14
Supply	25	41	14
Balance	0	0	0
Technicians			
Demand	57	96	33
Supply	59	98	33
Balance	2	2	0
Craftsmen			
Demand	395	778	329
Supply	387	791	350
Balance	-8	13	21

Note: 1) Net increase during the Plan period.

TABLE 17. KOREAN SCIENTIST AND ENGINEER DEMAND BY OCCUPATION
From KOREA (1971b), p. 59.

Occupation \ Year	1970	1972	1973	1974	1975	1976
Total	24 800	29 500	32 100	34 900	37 900	41 100
Architects, Civil Eng. & Surveyors	8 900	10 200	11 000	11 800	12 600	13 600
Elec. Eng., Elec. Equip. Eng. & Commun.	2 800	3 300	3 600	4 000	4 300	4 700
Mech. Eng.	3 100	3 800	4 300	4 700	5 200	5 700
Mining Eng.	500	500	500	600	600	600
Chem., Metall. & Ceramic Eng.	1 800	2 300	2 500	2 800	3 100	3 400
Agr., Fish. & Food Eng.	5 500	6 600	7 200	7 700	8 500	9 100
Textile Eng.	300	500	500	600	700	800
Natural Scientists	1 800	2 200	2 400	2 600	2 800	3 100
Other Eng.	100	100	100	100	100	100

TABLE 18. KOREAN SCIENTIST AND ENGINEER SUPPLY AND NET DEMAND BY OCCUPATION
From KOREA (1971b), p. 64-65.

Year	Supply & Net Demand / Occupation	Total	Architects, Civil Eng. & Surveyors	Elec. Eng., Elec. Equip. Eng. & Commun.	Mech. Eng.	Mining Eng.
Total	Net Demand	18 700	5 600	2 400	3 000	500
	Supply	40 100	4 000	5 200	3 300	1 000
	Balance	21 400	△ 1 600	2 800	300	500
1972	Net Demand	3 200	1 000	400	500	100
	Supply	6 600	700	700	600	200
	Balance	3 400	△ 300	300	100	100
1973	Net Demand	3 500	1 000	400	600	100
	Supply	7 400	600	900	600	200
	Balance	3 900	△ 400	500	—	100
1974	Net Demand	3 700	1 100	500	600	100
	Supply	8 700	900	1 200	700	200
	Balance	5 000	△ 200	700	100	100
1975	Net Demand	4 000	1 200	500	600	100
	Supply	8 700	900	1 200	700	200
	Balance	4 700	△ 300	700	100	100
1976	Net Demand	4 300	1 300	600	700	100
	Supply	8 700	900	1 200	700	200
	Balance	4 400	△ 400	600	—	100

Note: Figures for supply are present capacity of science and engineering colleges.

TABLE 18. KOREAN SCIENTIST AND ENGINEER SUPPLY AND NET DEMAND BY OCCUPATION (cont.)

Year	Supply & Net Demand \ Occupation	Chem., Metall. & Ceramic Eng.	Agr., Fish. & Food Eng.	Textile Eng.	Natural Scientists
Total	Net Demand	1 700	3 600	500	1 400
	Supply	5 200	6 000	1 800	13 600
	Balance	3 500	2 400	1 300	12 200
1972	Net Demand	300	600	100	200
	Supply	900	900	300	2 300
	Balance	600	300	200	2 100
1973	Net Demand	300	700	100	300
	Supply	1 000	1 200	300	2 600
	Balance	700	500	200	2 300
1974	Net Demand	300	700	100	300
	Supply	1 100	1 300	400	2 900
	Balance	800	600	300	2 600
1975	Net Demand	400	800	100	300
	Supply	1 100	1 300	400	2 900
	Balance	700	500	300	2 600
1976	Net Demand	400	800	100	300
	Supply	1 100	1 300	400	2 900
	Balance	700	500	300	2 600

Note: Figures for supply are present capacity of science and engineering colleges.

TABLE 19. KOREAN TECHNICIAN SUPPLY AND DEMAND BY OCCUPATION
From KOREA (1971b), pp. 66-67.

Year	Occupation / Supply & Net Demand	Total	Architecture, Civil & Survey Tech.	Elec. Tech., Elec. Equip. Tech. & Commun.	Mech. Tech.	Mining Tech.
Total	Net Demand	44 100	14 000	7 000	7 600	500
	Supply	44 100				
	Present Sup. Capacity.	18 500	3 400	2 200	2 800	500
	(Additional Sup. Plan)	(25 600)				
1972	Net Demand	7 500	2 400	1 200	1 300	100
	Supply	7 500				
	Present Sup. Capacity	4 400	700	600	700	100
	(Additional Sup. Plan)	(3 100)				
1973	Net Demand	8 300	2 600	1 300	1 500	100
	Supply	8 300				
	Present Sup. Capacity	3 200	500	400	500	100
	(Additional Sup. Plan)	(5 100)				
1974	Net Demand	8 700	2 800	1 400	1 500	100
	Supply	8 700				
	Present Sup. Capacity	3 300	600	400	400	100
	(Additional Sup. Plan)	(5 400)				
1975	Net Demand	9 400	3 000	1 500	1 600	100
	Supply	9 400				
	Present Sup. Capacity	3 800	800	400	600	100
	(Additional Sup. Plan)	(5 600)				
1976	Net Demand	10 200	3 200	1 600	1 700	100
	Supply	10 200				
	Present Sup. Capacity	3 800	800	400	600	100
	(Additional Sup. Plan)	(6 400)				

Note: ① Present supply capacity means that of the present technical junior colleges and junior colleges of science and technology.

② Additional supply plan is 7,800 from the expansion of technical junior college, 3,400 from vocational training and 14,400 from among surplus of scientists and engineers.

TABLE 19. KOREAN TECHNICIAN SUPPLY AND DEMAND BY OCCUPATION(cont.)

Year	Supply & Net Demand / Occupation	Chem., Metall. & Ceramic Tech.	Agr., Fish. & Food Tech.	Textile Tech.	Natural Tech.	Other Tech.
Total	Net Demand	3 700	7 100	2 000	1 700	500
	Supply Present Sup. Capacity. (Additional Sup. Plan)	1 500	4 300	500	2 300	1 000
1972	Net Demand	600	1 200	300	300	100
	Supply Present Sup. Capacity (Additional Sup. Plan)	300	1 200	100	500	200
1973	Net Demand	700	1 300	400	300	100
	Supply Present Sup. Capacity (Additional Sup. Plan)	300	700	100	400	200
1974	Net Demand	700	1 400	400	300	100
	Supply Present Sup. Capacity (Additional Sup. Plan)	300	800	100	400	200
1975	Net Demand	800	1 500	400	400	100
	Supply Present Sup. Capacity (Additional Sup. Plan)	300	800	100	500	200
1976	Net Demand	900	1 700	500	400	100
	Supply Present Sup. Capacity (Additional Sup. Plan)	300	800	100	500	200

Note: ① Present supply capacity means that of the present technical junior colleges and junior colleges of science and technology.

② Additional supply plan is 7,800 from the expansion of technical junior college, 3,400 from vocational training and 14,400 from among surplus of scientists and engineers.

TABLE 20. PERSONS ENGAGED IN KOREAN RESEARCH AND DEVELOPMENT
From KOREA (1972c), pp. 26-27.

(1968) Unit : Person

Organization \ Classification	Total	Researchers	Research Assistants	Others
Total	11,081	5,024	2,361	3,696
Gov't & Pub. Res. Inst.	4,881	1,712	1,119	2,050
Univ. & Col.	3,413	2,204	662	547
Non-profit Org.	1,086	471	154	461
Companies	1,701	637	426	638

(1969)

Organization \ Classification	Total	Researchers	Research Assistants	Others
Total	12,145	5,337	2,614	4,194
Gov't & Pub. Res. Inst.	5,291	1,987	1,292	2,012
Univ. & Col.	3,051	2,142	479	440
Non-profit Org.	1,229	426	223	580
Companies	2,564	782	620	1,162

(1970) Unit : Person

Organization \ Classification	Total	Researchers	Research Assistants	Others
Total	12,922	5,628	2,637	4,657
Gov't & Pub. Res. Inst.	5,056	1,962	1,075	2,018
Univ. & Col.	2,930	2,011	638	281
Non-profit Org.	1,360	496	176	688
Companies	3,577	1,159	748	1,670

(1971)

Organization \ Classification	Total	Researchers	Research Assistants	Others
Total	12,541	5,320	3,105	4,116
Gov't & Pub. Res. Inst.	6,012	2,049	1,494	2,469
Univ. & Col.	2,760	1,918	585	257
Non-profit Org.	1,422	428	408	586
Companies	2,347	925	618	804

TABLE 21. KOREAN RESEARCHERS BY FIELD

From KOREA (1972c), pp. 28-29.

Field \ Year / Organization	1970 Total	1970 Research Inst.	1970 Univ. & Col.	1970 Companies
Total	5,628	2,458	2,011	1,159
Math. & Physics	272	59	189	24
Chemistry	856	273	209	374
Biology	226	97	114	15
Geology	63	34	14	15
Civil Eng. & Arch.	346	133	145	68
Mech. Eng. & Naval Arch. Aircraft Eng.	338	67	87	184
Elec. Eng. & Telecom. Eng.	449	100	137	212
Mining & Metallurgy	278	118	81	79
Textiles	136	23	63	49
Agriculture & Forestry	1,032	829	173	30
Fisheries	163	144	4	15
Veterinary & Animal Husbandary	305	201	104	—
Medicine & Dentistry	316	72	234	10
Pharmacy	229	96	71	62
Others	266	86	158	22
Human & Cultural Science	354	126	228	—

Unit : Person

Field \ Year / Organization	1971 Total	1971 Research Inst.	1971 Univ. & Col.	1971 Companies
Total	5,320	2,477	1,918	925
Math. & Physics	260	65	169	26
Chemistry	754	244	202	308
Biology	230	82	130	18
Geology	201	180	14	7
Civil Eng. & Arch.	348	129	138	81
Mech. Eng. & Naval Arch. Aircraft Eng.	269	40	103	126
Elec. Eng. & Telecom. Eng.	322	89	141	92
Mining & Metallurgy	203	73	69	61
Textiles	149	39	46	64
Agriculture & Forestry	1,037	864	159	14
Fisheries	148	143	3	2
Veterinary & Animal Husbandary	312	64	243	5
Medicine & Dentistry	227	94	56	77
Pharmacy	227	94	56	77
Others	261	74	139	48
Human or Cultural Science	343	77	166	—

TABLE 22. PERSONS ENGAGED IN KOREAN RESEARCH INSTITUTES, UNIVERSITIES, AND COLLEGES
From KOREA (1972c), pp. 34-35.

Persons Engaged in R & D of Research Institutes

Unit : Person

Field	Classification	Total Employees	Researchers	Research Assistants	Others
	Total	7,434	2,477	1,902	3,065
Total	Natural Science	1,193	241	236	716
	Engineering	1,604	497	234	873
	Agriculture	3,406	1,312	963	1,131
	Medicine	594	250	79	266
	Others	619	171	379	65
	Sub-total	6,012	2,049	1,494	2,469
Gov't & Pub.	Natural Science	1,167	233	229	705
	Engineering	922	303	237	382
	Agriculture	3,358	1,278	953	1,127
	Medicine	565	235	75	255
	Others	—	—	—	—
	Sub-total	1,422	426	408	586
Private	Natural Science	23	8	7	11
	Engineering	704	203	8	486
	Agriculture	48	34	10	4
	Medicine	29	15	4	10
	Others	615	171	379	65

Persons Engaged in R & D of Universities and Colleges

Unit : Person

Field	Classification	Total Employees	Researchers	Research Assistants	Others
	Total	2,760	1,918	585	257
Total	Natural Science	416	302	89	25
	Engineering	1,156	759	274	123
	Agriculture	436	387	26	23
	Medicine	426	260	105	61
	Others	326	210	91	25
	Sub-total	1,300	934	236	130
Gov't & Pub.	Natural Science	170	144	17	9
	Engineering	547	373	91	83
	Agriculture	304	271	18	15
	Medicine	173	85	67	21
	Others	106	61	43	2
	Sub-total	1,460	984	349	127
Private	Natural Science	246	158	72	16
	Engineering	609	386	163	40
	Agriculture	132	116	8	8
	Medicine	253	175	38	40
	Others	220	149	48	23

TABLE 23. PERSONS ENGAGED IN RESEARCH AND DEVELOPMENT IN KOREAN COMPANIES

From KOREA (1972c), p. 40.

Unit : Person

Industry \ Classification	Total Employees	Researchers	Research Assistants	Others
Total	2,347	925	618	804
Agr., Forestry & Fisheries	95	47	14	34
Mining	82	40	18	24
Construction	57	31	13	13
Trans. Elec. Gas. & Pub. Works	247	167	52	28
Manufacturing	1,866	640	521	705
Foods	115	57	17	41
Textile	183	43	67	73
Lumber	57	18	17	22
Printing	39	24	8	7
Rubber Products	243	82	90	71
Chemical Products	534	249	186	99
Petroleum & Coal Products	265	7	12	246
Ceramics	48	21	17	10
Basic Metal	121	41	31	49
Metal Products				
Machinery	128	23	43	62
Elec. Machinery	89	55	23	11
Trans. Mach.	35	16	8	11
Others	9	4	2	3

TABLE 24. KOREAN LONG-TERM DEMAND, REQUIREMENT, AND SUPPLY FOR SCIENTIFIC AND TECHNICAL MANPOWER BY CATEGORY

From KOREA (1970), pp. 22, 32 and 33.

Unit: 1.000 persons

Classification / Year	Total		Scientists & Engineers		Technicians		Craftsmen	
	Demand	%	Demand	%	Demand	%	Demand	%
1967	342.8	100.0	13.9	4.1	56.4	16.4	272.5	79.5
1976	934.1	100.0	43.0	4.6	112.3	12.0	778.8	83.4
1986	2.427.4	100.0	153.1	6.3	297.2	12.2	1,977.1	81.5
Average Annual Increase Rate(%)	(10.4)		(12.7)		(8.7)		(10.4)	

Unit: Person

Period / Req. & Supply / Category	Total		1967~1971		1972~1976		1977~1981		1982~1986	
	Requirement	Supply	Requirement	Supply	Requirement	Supply	Repuirement	Supply	Requirement	Supply
Total	2 772 300	791 100	238 700	151 800	533 700	213 100	718 000	213 100	1 281 900	213 100
Scientists & Engineers	176 700	157 500	10 700	32 400	26 300	41 700	45 200	41 700	94 500	41 700
Technicians	280 000	87 200	21 300	17 600	45 500	23 200	72 900	23 200	140 300	23 200
Craftsmen	2 315 600	546 400	206 700	101 800	461 900	148 200	599 900	148 200	1 047 100	148 200

TABLE 24 (Con't)

※ DEFINITION USED IN THE FORECAST

1. Scientist & Engineer:

An engineer is one, who gradusted from a science and engineering college (including old system of colleges) or has the same qualifications, and who plans, designs and directs complete production facilities including the construction or fabrication of structures, devices, systems, and processes, using advanced principles of engineering science.

Scientists perform complicated physical, mathematical, biological, or other research aimed at overall industrial or social development, or the extension of knowledge.

2. Technician:

A technician is one who worke in direct support of engineers or scientis's, utilizing theoretical knowledge of fundamental scientific, engineering, mathematical, or draft design principles.

3. Craftsman:

A craftsman is one who is engaged in or directly associated with manufacturing processes and the construction, manipulation, maintenance, and repair of various types of highway, structures, machines and other products, and workers who are engaged in the extraction of solids, semi-liquids, liquids and gases from the earth, both of whose jobs require more than six months in mastering them. Engineers and technicians are not included in the definition, however.

TABLE 25. MIGRATION OF KOREANS TO THE UNITED STATES, 1962-68
From CIMT (1970), p. 137.

Categories	1962	1964	1966	1967	1968
Total	1,538	2,362	2,492	3,956	3,811
Professional and Technical	109	134	349	830	716
Total Engineers and Scientists	33	33	104	194	n.a.
Engineers	16	19	53	108	n.a.
Natural Scientists	17	14	51	86	n.a.

Source: Annual Report(s) of the U.S. Immigration and Naturalization Service; The Brain Drain into the United States of Scientists, Engineers, and Physicians, A Staff Study for the Research and Technical Programs Subcommittee of the Committee on Government Operations, House of Representatives, 90th Cong., 1st Sess. July, 1967, Tables I-VI (Washington, D. C.: U.S. Government Printing Office, 1967); The Brain Drain of Scientists, Engineers, and Physicians from the Developing Countries into the United States, Hearing before a Subcommittee on Government Operations, House of Representatives, 90th Cong., 2nd Sess., January 23, 1968, Appendix Table 1 (Washington, D. C.: U.S. Government Printing Office, 1968).

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TABLE 26. OUTFLOW OF KOREAN PROFESSIONAL, TECHNICAL, AND KINDRED WORKERS IN RELATION TO THE STOCK AND DEMAND FOR HIGH-LEVEL MANPOWER
From CIMT (1970), p. 140. All figures for 1966, except where noted. The author's compilation (Heather Low Ruth).

Natural Scientists and Engineers

Natural Scientists and Engineers	Estimated Minimum Total Korean Emigrants	Korean Emigrants to United States Only
Number	159	133
As Proportion of: Enrollment in Engineering and Sciences	.003	.003
Estimated Output from Science and Engineering Faculties	.018	.015
Estimated Stock of Scientists and Engineers in 1967	.030	.025
Estimated Demand for Scientists and Engineers in 1967	.042	.036
Estimated Excess in Supply over Demand for Scientists and Engineers in 1967	.103	.086

TABLE 27. KOREAN INVESTMENT FOR RESEARCH AND DEVELOPMENT
From KOREA (1970), p. 14.

Unit: GNP Billion Won
Others Million Won

Classification \ Year	63	64	65	66	67	68	69
G N P	487.96	696.97	805.85	1,032.04	1,242.35	1,575 65	2,030.14
R & D	1,404.0	1,581.0	2,395.0	3,702.0	5,880.4	7,456 3	10 281.7
1)Government	1,232.0	1,375.0	2.065.0	3,164.0	4,730.2	6.288.3	8.510.1
2)Private	172	206	330	538	1,150.0	1,168.0	1,771.6
To GNP (%)	0.3	0.2	0 3	0.4	0.47	0.47	0.56

TABLE 28. KOREAN RESEARCH AND DEVELOPMENT EXPENDITURES BY SOURCE AND PERFORMANCE
From KOREA (1972c), p. 22-23.

(1968) Unit : 1,000Won

Performance \ Source		R & D Exp.	Gov't & Pub. Amount	Gov't & Pub. Ratio	Private Amount	Private Ratio
Grand Total		6,687,491	5,695,645	85	991,946	15
Research Institutes	Total	5,611,497	5,561,868	99	49,629	1
	Gov't & Pub.	3,999,321	3,999,321	100	-	0
	Private	1,612,176	1,562,547	97	49,629	3
Univ. & Col.	Total	352,363	132,667	38	219,696	62
	Gov't & Pub	172,856	80,020	46	92,836	54
	Private	179,507	52,647	29	126,860	71
Companies		723,631	1,010	0.2	722,621	99.8

(1970)

Performance \ Source		R & D Exp.	Gov't & Pub. Amount	Gov't & Pub. Ratio	Private Amount	Private Ratio	Foreign Amount	Foreign Ratio
Grand Total		10,547,753	7,414,080	70.3	3,023,261	28.7	110,412	1.0
Research Institutes	Total	8,851,762	7,185,072	81.2	1,639,275	18.5	27,414	0.3
	Gov't & Pub	6,171,354	6,169,583	99.9	211	--	1,560	0.025
	Private	2,680,409	1,015,489	37.9	1,639,06[illegible]	61.1	25,854	0.9
Univ. & Col.	Total	371,135	142,797	38.5	145,3[illegible]	39.2	82,998	22.4
	Gov't & Pub	107,640	82,207	76.4	12,337	11.5	13,096	12.2
	Private	263,495	60,590	23.0	133,0[illegible]	50.5	69,903	26.6
Companies		1,324,859	86,211	6.5	1,238,64[illegible]	93.5	—	—

(1969)

Performance \ Source		R & D Exp.	Gov't & Pub. Amount	Gov't & Pub. Ratio	Private Amount	Private Ratio	Foreign Amount	Foreign Ratio
Grand Total		9,773,985	7,154,075	73.3	1,777,058	18.1	842,852	8.6
Research Institutes	Total	8,445,790	7,063,356	83.5	600,262	7.1	792,172	9.4
	Gov't & Pub	5,982,725	5,981,038	99.9	70	—	1,617	0.1
	Private	2,463,065	1,072,318	43.6	600,192	24.4	790,555	32.0
Univ. & Col.	Total	331,506	94,907	28.6	185,919	56.1	50,680	15.3
	Gov't & Pub	65,583	61,080	90.0	4,003	7.0	500	3.0
	Private	265,923	33,827	12.4	181,910	68.1	50,180	15.0
Companies		996,689	5,812	0.6	990,877	99.4	—	—

(1971)

Performance \ Source		R & D Exp.	Gov't & Pub. Amount	Gov't & Pub. Ratio	Private Amount	Private Ratio	Foreign Amount	Foreign Ratio
Grand Total		10,666,711	7,285,837	68.3	2,968,903	27.7	411,971	4
Research Institutes	Total	8,795,983	6,874,657	77.8	1,602,748	18.3	318,578	3.9
	Gov't & Pub	5,655,812	5,626,644	99.4	29,168	0.6	—	—
	Private	3,140,171	1,248,013	39.0	1,573,580	50.2	318,578	10.8
Univ. & Col.	Total	572,173	312,789	54.6	229,819	40.1	29,565	5.3
	Gov't & Pub	250,711	197,334	78.7	53,375	21.3	—	—
	Private	321,461	115,455	35.9	176,441	54.8	29,565	9.3
Companies		1,298,555	98,391	6.7	1,136,336	88.1	63,828	5.2

TABLE 29. KOREAN RESEARCH AND DEVELOPMENT EXPENDITURES BY ITEM
From KOREA (1972c), pp. 24-25.

(1968)

Unit : 1,000 Won

Organization \ Item	Total	Wages & Salaries	Expendibles	Fixed Assets	Others
Total	6,687,491	1,561,916	854,880	3,266,177	1,004,518
Gov't & Pub. Res. Inst.	3,999,321	996,988	617,026	1,704,455	680,852
Univ. & Col.	352,363	119,947	55,466	121,540	25,410
Non-profit Org.	1,412,176	109,470	48,121	1,247,516	207,069
Companies	723,631	335,511	104,267	192,656	91,187

(1969)

Organization \ Item	Total	Wages & Salaries	Expendibles	Fixed Assets	Others
Total	9,773,985	2,385,347	1,507,306	4,570,585	1,306,745
Gov't & Pub. Res. Inst.	5,982,725	1,410,510	1,186,314	2,638,176	747,726
Univ. & Col.	331,506	81,359	67,759	151,598	30,790
Non-profit Org.	2,463,066	402,020	102,015	1,501,157	457,873
Companies	996,689	496,458	151,220	279,654	70,357

(1970)

Organization \ Item	Total	Wages & Salaries	Expendibles	Fixed Assets	Others
Total	10,547,753	2,960,472	2,060,327	2,961,214	2,565,740
Gov't & Pub. Res. Inst.	6,171,356	1,655,072	1,420,013	1,760,413	1,335,886
Univ. & Col.	371,132	133,457	96,383	83,471	57,838
Non-profit Org.	2,680,408	540,678	279,737	864,175	995,808
Companies	1,324,869	631,365	284,129	233,155	176,210

(1971)

Organization \ Item	Total	Wages & Salaries	Expendibles	Fixed Assets	Others
Total	10,463,667	3,040,191	2,235,652	2,358,314	2,829,210
Gov't & Pub. Res. Inst.	5,565,876	1,625,557	1,363,737	1,582,092	994,430
Univ. & Col.	569,873	240,826	103,505	112,609	112,936
Non-profit Org.	3,138,701	571,728	512,926	490,038	1,564,009
Companies	1,189,117	602,080	256,686	173,575	157,776

TABLE 30. RESEARCH AND DEVELOPMENT EXPENDITURES OF KOREAN RESEARCH INSTITUTES

From KOREA (1972c), pp. 32, 33.

Unit : 1,000Won

Field	Classification	No. of Inst.	R & D Exp.	Wages & Salaries	Item: Expendibles	Item: Fixed Assets	Item: Others	Character of Work: Basic Res.	Character of Work: Applied Res.	Character of Work: Development
Total	Total	106	8,704,577	2,197,285	1,876,663	2,072,130	2,558,499	1,589,813	1,996,674	4,659,496
	Natural Science	9	1,135,178	238,039	228,960	403,736	264,443	609,863	79,230	397,391
	Engineering	20	3,678,591	638,284	450,649	911,285	1,678,373	348,000	299,733	2,954,466
	Agriculture	65	3,252,840	1,097,067	946,877	692,256	516,640	469,030	1,430,971	1,067,222
	Medicine	15	298,639	101,472	87,484	69,271	50,412	74,373	149,289	27,286
	Others	7	339,129	122,423	162,693	5,582	48,431	88,547	37,451	213,131
Gov't & Pub.	Sub-total	85	5,565,876	1,625,557	1,363,737	1,582,092	994,490	1,483,416	1,870,732	1,749,496
	Natural Science	6	1,135,058	237,799	228,880	403,736	264,643	508,576	77,651	396,298
	Engineering	14	895,954	195,096	105,965	429,329	165,604	332,557	215,341	271,704
	Agriculture	52	3,247,818	1,095,370	945,687	690,256	616,505	468,410	1,429,951	1,063,840
	Medicine	13	287,006	97,292	83,205	58,771	47,738	73,873	147,789	17,653
	Others	—	—	—	—	—	—	—	—	—
Private	Sub-total	21	3,138,701	571,728	512,926	490,038	1,564,009	106,397	125,942	2,910,001
	Natural Science	3	320	240	80	—	—	1,287	1,579	1,093
	Engineering	6	2,782,597	443,188	344,684	481,956	1,512,769	15,443	84,392	2,682,762
	Agriculture	3	5,022	1,697	1,190	2,000	135	620	1,020	3,382
	Medicine	2	11,633	4,180	4,279	500	2,674	100	1,500	9,633
	Others	7	339,129	122,423	162,693	5,582	48,431	88,147	37,451	213,131

TABLE 31. RESEARCH AND DEVELOPMENT EXPENDITURES OF KOREAN UNIVERSITIES AND COLLEGES
From KOREA (1972c), pp. 36-37.

Unit : 1,000Won

Field	Classification	No. of Inst.	R & D Exp.	Wages & Salaries	Item: Expendibles	Item: Fixed Assets	Item: Others	Character of Work: Basic Res.	Character of Work: Applied Res.	Character of Work: Development
Total	Total	81	569,873	240,826	103,503	112,609	112,935	226,455	175,971	143,447
	Natural Science	13	34,005	17,405	6,141	5,405	5,414	16,595	13,630	3,780
	Engineering	18	330,746	137,358	52,115	95,774	45,499	132,548	118,663	76,536
	Agriculture	16	48,993	18,646	14,121	740	15,586	12,068	16,104	20,821
	Medicine	18	111,128	43,546	23,427	8,673	35,482	56,015	15,032	40,081
	Others	16	45,001	24,331	7,699	2,017	24,001	9,229	12,542	2,230
Gov't & Pub.	Sub-total	32	249,912	131,496	37,653	38,079	42,684	116,940	97,863	32,109
	Natural Science	4	4,600	2,340	1,400	—	860	1,700	2,100	800
	Engineering	7	185,352	100,722	15,221	35,769	33,640	99,947	80,155	2,2[illegible]0
	Agriculture	11	31,235	13,386	12,203	160	5,486	6,359	10,941	13,9[illegible]5
	Medicine	7	23,945	2,095	8,659	2,150	183	8,934	1,517	13,494
	Others	3	4,780	12,953	170	—	2,515	—	3,150	1,630
Private	Sub-total	49	319,961	109,330	65,850	74,530	70,251	109,51[illegible]	78,104	111,338
	Natural Science	9	29,405	14,705	4,741	5,405	4,554	14,895	11,530	2,980
	Engineering	11	145,394	36,636	36,894	60,005	11,859	32,601	38,508	74,285
	Agriculture	6	17,758	5,160	1,918	580	10,000	5,[illegible]00	5,163	6,886
	Medicine	11	87,163	39,593	14,768	6,523	35,259	47,081	13,515	26,587
	Others	13	40,221	22,236	7,529	2,017	8,439	9,229	9,392	600

Note : Total R & D expenditures of universities and colleges by character of work are estimated.

TABLE 32. RESEARCH AND DEVELOPMENT EXPENDITURES FOR KOREAN COMPANIES
From KOREA (1972c), pp. 38,39.

Unit : 1,000Won

Classification / Industry	No. of Companies	R & D Exp.	Wages & Salaries	Item: Expendibles	Item: Fixed Assets	Item: Other	Character of Work: Basic Res.	Character of Work: Applied Res.	Character of Work: Development
Total	118	1,189,117	602,080	255,686	173,576	157,776	133,117	470,056	582,864
Agr., Forestry & Fisheries	3	83,596	39,080	13,590	11,715	29,211	3,682	—	89,914
Mining	5	39,589	29,723	7,433.	195	2,238	10,735	13,033	15,821
Construction	4	41,328	23,866	5,973	842	10,647	3,610	9,280	28,538
Trans. Elec.	2	173,779	82,742	37,583	22,588	30,866	11,996	150,793	6,056
Manufacturing	104	840,825	425,669	191,107	138,235	84,814	103,094	296,950	442,635
Foods	6	67,809	33,980	13,574	17,075	3,200	6,952	17,722	44,135
Textile	17	17,304	8,132	3,500	5,132	540	1,441	10,933	4,927
Lumber	2	29,404	2,160	23,888	627	2,729	—	--	29,404
Printing	3	61,419	32,228	6,718	5,257	17,216	105	15,845	45,469
Rubber Products	7	100,003	67,132	11,358	18,828	2,685	12,752	21,461	65,790
Chemical Products	28	363,036	190,131	70,205	61,888	40,812	69,572	147,213	146,251
Petroleum & Coal Prod.	4	20,632	12,910	1,525	4,827	1,370	9,559	4,546	10,856
Ceramics	6	41,144	23,666	2,471	13,960	1,147	-	17,908	23,236
Basic Metal	7	30,227	5,188	23,775	200	1,064	1,631	21,918	6,675
Metal Products	1	—	—	—	—	—	—	—	—
Machinery	3	34,269	18,484	9,957	2,919	2,909	1,152	2,715	30,402
Elec. Machinery	6	25,852	7,296	13,140	4,861	1,556	100	110	23,977
Trans. Mach.	6	44,290	22,029	10,708	2,350	9,203	50	35,820	8,390
Others	13	4,436	3,454	288	311	383	771	759	3,023

TABLE 33. KOREAN RESEARCH ORGANIZATIONS AND EXPENDITURES
From KOREA (1972c), pp 30, 31.

R & D Expenditures per Researcher

Unit : 1,000Won

Year / Organization	66	67	68	69	70	71
Average	1,068	1,193	1,331	1,831	1,874.2	2,005
Research Inst.	1,211.4	2,243.0	2,670.5	3,600.1	3,601.2	3,558
Univ. & Col.	703.8	97.6	159.9	154.8	184.6	301
Companies	1,412.3	754.4	1,136.9	1,274.6	1,143.1	1,404

Number of Research Organizations

Year / Classification	65	66	67	68	69	70	1971				
							Total	Sci. & Eng.	Agr.	Med.	Others
Grand Total	105	108	223	273	290	297	306	163	74	45	23
Research Institutes	65	68	74	96	96	105	106	29	55	15	7
Universities and Colleges	18	18	51	77	80	85	81	31	16	18	16
Companies	22	22	98	100	104	107	118	103	3	12	—

Science and Technology Budget*

Unit : Million Won

Classification / Year	A Gov't Budget	B Sci. & Tec. Budget	B/A	C Administrative Exp.	C/B
1968	262,064.0	6,814.4	2.6	265.8	3.9
1969	370,532.0	9,076.6	2.4	412.2	4.5
1970	446,273.0	9,716.4	2.2	436.6	4.49
1971	555,345.0	10,315.2	1.9	549.6	5.32

Classification / Year	D Budget of Gov't & Pub. Res. Inst.	D/B	E Exp. on Facilities of Nat Univ. & Col	E/B
1968	3,999.3	61.7	571.2	8.4
1969	5,982.7	65.9	876.6	9.7
1970	6,171.4	63.5	1,317.6	13.6
1971	5,655.8	54.8	1,897.5	18.4

Classification / Year	F Others	F/B	G GNP	B/G
1968	1,978.1	29.0	1,575,650	0.43
1969	1,805.1	19.9	2,047,110	0.44
1970	1,763.8	18.2	2,561,950	0.38
1971	2,212.3	21.4	3,085,820	0.34

* Includes the total budget for national research organizations, administrative expenditures of MOST, expenditures for science and technical facilities for national universities, and subsides for science and technology.

TABLE 34. BUDGET OF THE KOREAN MINISTRY OF SCIENCE AND TECHNOLOGY

From KOREA (1972c), p. 41.

By Organization

Unit : 1,000 Won

Agency \ Year	1969	1970	1971	1972
Total	3,629,616.0	3,445,711.1	4,638,194.0	4,927,812.0
MOST (Main Office)	1,763,749.4	1,587,163.3	2,488,297.0	2,777,077.0
Office of Atomic Energy	1,096,493.5	992,456.2	1,040,525.0	832,826.0
Geological Survey of Korea	301,076.4	321,282.9	374,711.0	388,728.0
Office of Central Meteorology	370,727.4	274,708.6	335,022.0	392,619.0
National Science Museum	97,570.3	100,127.1	89,485.0	117,098.0
National Computer Center	—	164,978.0	310,154.0	419,464.0

By Account

Account \ Year	1969	1970	1971	1972
Total	3,629,616.0	3,445,711.1	4,638,194.0	4,927,812.0
General Account	930,036.9	1,052,846.4	1,320,861.0	1,495,328.0
Special Account	2,425,420.6	2,250,564.3	3,317,333.0	3,210,484.0
Claim Fund Management	274,158.6	142,300.4	—	222,000.0

TABLE 35. KOREAN INVESTMENT PROGRAMS FOR THE PLAN PERIOD 1972-1976, IN MILLION WONS, AT 1970 PRICES
From KOREA (1971a), pp. 192-193.

Sector	*Description of Project*	*Total*	*Government*			*Private*
			Sub-Total	*Central*	*Local*	
Health		40,429	27,082	17,795	9,287	13,347
Expansion of Medical Facilities and Disease	Expansion of hospital beds 7,051 beds.	13,303	6,130	4,835	1,295	7,173
Control	Reinforcement of disease control including T.B., leprosy, acute epidemic and parasite	4,660	4,660	3,562	1,098	—
Family Planning, Maternal and Child Health Services	Expansion of family planing and Birth Attendance services, etc.	6,259	6,259	4,218	2,041	—
Improvement of Living Environment	Simple Pipe Water Supply Facilities, Sanitary wells. etc.	16,207	10,033	5,180	4,853	6,174
Housing	Housing Construction 800 thous. Houses and Construction of Housing Estates	382,670	43,781	10,945	32,836	338,889
Science and Technology	Advanced technology inducement and Promotion of Research and Development	53,896	32,705	32,705	—	21,191
Others		384,595	99,611	24,045	75,566	284,984

TABLE 36. KOREAN INVESTMENT OUTLAYS ON MANPOWER DEVELOPMENT AND TECHNOLOGICAL RESEARCH PROGRAMS
From KOREA (1971a), p. 86.

(1972-1976)

In million won

	Government	*Private*	*Total*
Total Investment [1]	248,632	72,651	321,283
Education and manpower development program	203,264	51,460	254,724
Science and technology development program	45,368	21,191	66,559

Note: 1) Includes funds allocated in other sectors.

TABLE 37. SOME DETAILS OF THE KOREAN INVESTMENT PROGRAM IN MANPOWER DEVELOPMENT

From WON (1972), pp. 30-31.

(At 1970 Prices) Unit: Million Won

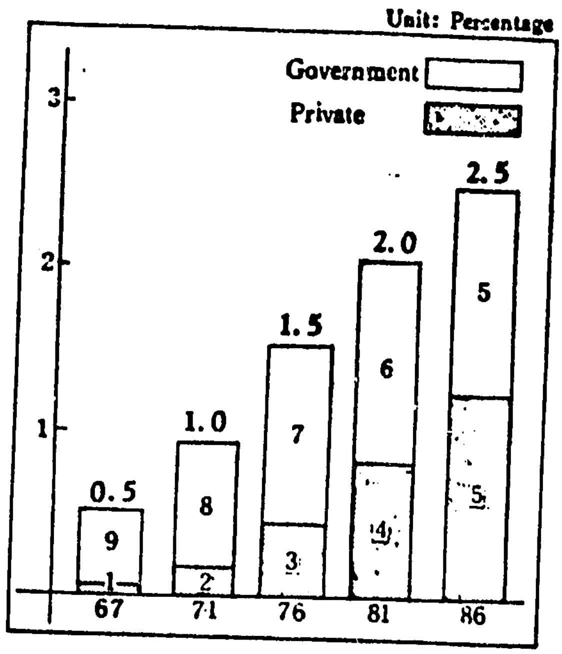
Sector	Project	Investment('72-'76) Total	Govern-ment	Private
Manpower Development		76 074 (254 724)	56 192 (216 954)	19 882 (37 770)
Scientific & Technical Manpower		51 040	34 327	16 713
Establishment of New Schools	87 tech. middle schools, tech. junior colleges, vocational high schools and other tech. schools	20 690	13 622	7 068
Reorganization of Departments	110 vocational high school and tech. junior college classes	2 228	2 228	—
Expansion of facilities	Expansion of facilities of vocational high schools, tech. junior colleges and science and eng. colleges up to 60% of the set standard	24 969	15 324	9 645
Others		3 153	3 153	—
Vocational Training		13 690	13 690	—
Training & Facilities	Expansion of vocational training facilities and the training of 263 thousand technicians and craftsmen	12 819	12 819	—
Skill Tests	Skill testing of 526 thousand persons	871	871	—

TABLE 38. KOREAN LONG-TERM INVESTMENT PLAN FOR RESEARCH AND DEVELOPMENT
From KOREA (1970), pp. 30, 31.

(1 9 6 7 Price) Unit: Billion won

	1967		1968		1969		1970		1971		1967~1971		1972~1976		1977~1981		1982~1986	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
Total Investment	5.64	100.0	8.70	100.0	9.48	100.0	13.43	100.0	16.92	100.0	54.17	100.0	151.00	100.0	347.04	100.0	691.62	100.0
Government	3.80	67.4	5.80	66.7	6.93	73.1	9.44	70.3	11.57	68.4	37.54	69.3	98.01	64.9	199.36	57.4	307.77	44.5
Government Research Institutes	2.79	49.5	4.63	53.2	5.91	62.3	8.25	61.4	10.22	60.4	31.80	58.7	80.49	53.3	157.45	45.4	220.51	31.9
National Universities	1.01	17.9	1.17	13.5	1.02	10.8	1.19	8.9	1.35	8.0	5.74	10.6	17.52	11.6	41.91	12.0	87.26	12.6
Private	1.84	32.6	2.90	33.3	2.55	26.9	3.99	29.7	5.35	31.6	16.68	30.7	52.99	35.1	147.68	42.6	383.85	55.5
Private Universities and Non-profit Corp.	1.04	18.4	1.94	22.2	1.55	16.4	1.74	12.9	1.84	10.9	8.10	14.9	19.81	13.1	39.67	11.4	75.39	10.9
Enterprises	0.80	14.2	0.97	11.1	1.00	10.5	2.25	16.8	3.51	20.7	8.53	15.8	33.18	22.0	108.01	31.2	308.46	44.6
Basic Sciences	1.12	19.9	1.87	21.5	1.43	15.1	2.43	18.1	2.58	15.2	9.43	17.4	23.71	15.7	43.38	12.5	71.93	10.4
Agriculture & Fisheries Technique	1.22	21.6	1.65	19.0	2.47	26.0	2.91	21.7	3.59	21.2	11.84	21.8	27.67	18.3	51.01	14.7	75.39	10.9
Mining & Manufacturing Technique	2.34	41.5	3.67	42.2	3.45	36.4	5.51	41.0	7.55	44.6	22.52	41.6	75.23	49.8	196.78	56.7	437.10	63.2
Social Overhead and Other Services	0.96	17.0	1.51	17.3	2.13	22.5	2.58	19.2	3.20	19.0	10.38	19.2	24.39	16.2	55.87	16.1	107.20	15.5
Basic Research	1.12	19.9	1.87	21.5	1.43	15.1	2.43	81.1	2.58	15.2	9.43	17.4	23.71	15.7	43.38	12.5	71.93	10.4
Applied Research	2.83	50.1	4.28	49.2	4.64	48.9	6.53	48.6	8.19	48.4	26.47	48.9	70.21	46.5	149.57	43.1	278.72	40.3
Development Research	1.69	30.0	2.55	29.3	3.41	36.0	4.47	33.3	6.15	36.4	18.27	33.7	57.08	37.8	154.09	44.4	340.97	49.3
Research Expenditure	3.50	62.0	5.45	62.6	6.82	71.9	9.29	69.2	10.17	60.1	35.23	65.0	83.65	55.4	139.16	40.1	446.79	64.6
Fixed Capital Formation	2.14	38.0	3.25	37.4	2.66	28.1	4.14	30.8	6.75	39.9	18.94	35.0	67.35	44.6	207.88	59.9	244.83	35.4

TABLE 39. KOREAN LONG-TERM INVESTMENT PLAN FOR RESEARCH AND DEVELOPMENT (Ratio to GNP)
From KOREA (1970), p. 21.



PUBLISHER'S NOTE:

PAGE NUMBER(S) 92 COULD NOT BE LOCATED.

TABLE 41. ESTIMATED EMPLOYMENT IN SELECTED OCCUPATIONS IN MEDIUM AND LARGE-SCALE NIGERIAN INDUSTRY[1]

From NIGERIA (1970), p. 330.

Occupation Group[2]	*Estimated Employment*		*Additional Employment Requirements, 1970-1974*
	1970	1974	
Directors, Managers, etc.	17,039	21,122	4,083
Engineers, Total	4,460	5,841	1,381
Mechanical	1,324	1,776	452
Electrical	940	1,240	300
Civil	885	1,067	182
Others	1,311	1,758	447
Doctors[3]	2,100	2,700	600
Accountants/Auditors	1,379	1,801	422
Architects/Town Planners	136	190	54
Surveyors	320	393	73
Physicists/Chemists	739	941	202
Biologists, etc.	187	218	31
Economists, etc.	345	416	71
Graduate Teachers	6,168	7,688	1,520
Other Senior Staff	12,781	17,551	4,770
TOTAL, SENIOR STAFF	45,654	58,861	13,207
Junior Managers, Supervisors, etc.	50,276	66,131	15,855
Draughtsmen	1,064	1,453	389
Technical Assistants	5,125	6,472	1,347
Laboratory Technicians	2,201	2,793	592
Accounting Assistants	2,106	2,675	569
Nurses	6,968	8,715	1,747
Medical Technicians	645	800	155
Work Supervisors	6,206	8,363	2,157
Non-graduate Teachers[4]	48,025	52,832	4,807
Other Junior Staff	4,263	9,023	4,760
TOTAL, INTERMEDIATE CATEGORY	126,879	159,257	32,378

1 Data cover establishments employing 10 or more persons, except in the case of doctors, for whom total employment has been estimated. Therefore, estimates in this table for occupations with significant employment in small establishments, such as non-graduate teachers, may be considerably lower than total requirements. Although data are shown in unrounded form for statistical purposes, they should be considered only as estimates.

2 The occupational classification system used is the International Standard Classification of Occupations.

3 These data are based on current enrolments in medical schools and the likely return of Nigerian medical practitioners from abroad (but excluding any significant increase in the number of expatriate doctors). Under even the most favourable circumstances, the total number of medical practitioners in Nigeria is not expected to exceed 3,000 in 1974. Merely to maintain the current ratio of doctors to population—about one doctor per 30,000 population but with extreme regional differences—approximately 3,855 doctors would be required in 1974.

4 Data compiled by the Ministry of Education indicate a number of non-graduate teachers significantly higher than shown in this Table. The difference between the two sources results from the inclusion in the Table of only schools employing 10 or more persons, as well as other slight differences in coverage and concepts. Estimates for the total number of non-graduate teachers are presented below:

1970	*1974*	*Change between 1970-1974*
90,000	100,000	10,000

The 1970 estimate assumes the return to operation of all schools in the war-affected areas.

TABLE 42. NIGERIAN EXPENDITURE ON RESEARCH AND DEVELOPMENT
From UNESCO (1969a), p. 86.

RESEARCH GROUPING	FINANCING SECTOR (in £ millions) 1966/67			TOTAL
	Government	University	Private industry	
Industrial	0.37	0.16		0.53
Natural environment	3.79	0.06		3.85
Agriculture (extension)	4.30 (2.94)	0.11 (-)	Not	4.41 (2.94)
Medicine	0.30	0.28	yet available	0.58
Social science	0.12	0.10		0.22
Miscellaneous	0.17	0.01		0.18
Total (+ extension)	9.05 (11.99)	0.72 (-)		9.77 (12.71)

TABLE 43. RESEARCH IN NIGERIAN INSTITUTES AND MINISTRIES
From UNESCO (1969a), p. 83

A. Research Institutes.

(i) Nigerian Institute of Trypanosomiasis Research (NITR)
(ii) Nigerian Institute of Oil Palm Research (NIFOR)
(iii) Cocoa Research Institute of Nigeria (CRIN)
(iv) Rubber Research Institute of Nigeria (RRIN)
(v) Federal Institute of Industrial Research (FIIR)
(vi) Federal Building Research Institute (FBRI)
(vii) Nigerian Stored Products Research Institute (NSPRI) (still administered by the Federal Ministry of Trade)
(viii) Nigerian Institute of Social and Economic Research (NISER)

B. Ministries.

(i) Federal Ministry of Agriculture and Natural Resources: Agricultural Research, Forestry Research, Veterinary Research, Fisheries Service and Meteorological Service;
(ii) Federal Ministry of Health: Medical Research, Government Chemist, Federal Laboratories Service and Forensic Science Unit;
(iii) Federal Ministry of Mines and Power: Geological Survey Division and Research Unit of the Mines Division;
(iv) Federal Ministry of Works and Housing: Land Survey and Materials Testing Laboratory.

TABLE 44. DETAILS OF THE TURKISH EDUCATIONAL SYSTEM
From TURKEY (1969), pp. 193, 197.

Total Investment in Education (In Million TL) *

	1968 - 1969 (1)	1969 - 1970 (2)	1970 - 1971 (3)	1971 - 1972 (4)	1972 - 1973 (5)	Total (6)
rimary Schools	537.6	472.5	361.0	602.0	226.9	2 200.0
econdary Schools	247.6	322.1	427.3	326.4	281.6	1 605.0
ligh Schools (Lycées)	65.8	91.7	136.5	191.4	229.2	714.6
gricultural Schools	3.3	3.9	4.2	4.2	4.7	20.3
'illage Midwife Schools	2.2	3.2	4.2	4.2	3.9	17.7
ncillary Medical Personnel Schools	17.1	21.9	26.7	53.0	51.3	170.0
'echnical Schools	11.5	24.2	91.5	109.7	133.0	369.9
'rade & Tourism Schools	16.8	23.4	35.6	50.1	60.4	186.3
'ocational Schools for Girls	8.5	11.1	8.0	9.2	9.8	46.6
chools for Training Primary School Teachers	58.8	39.9	46.6	60.4	71.6	277.3
'eacher Training Schools	29.3	48.1	38.3	38.9	50.0	204.6
ligher Education (Technical and Science)	101.2	88.5	107.5	134.3	165.3	596.8
ligher Education (Medicine and Health)	27.3	19.9	58.5	52.8	60.5	219.0
ligher Education (Agriculture)	12.1	13.0	15.7	16.9	19.0	76.7
ligher Education (General)	30.5	32.8	33.5	32.0	34.4	163.2
)ther Educational Investments	68.2	94.6	62.0	61.5	345.7	632.0
'otal	1 237.8	1 310.8	1 457.1	1 747.0	1 747.3	7 500.0

* Note : The above investments indicate the magnitudes calculated taking into consideration the capacity increases. The continuing investments and the final investment figures will be disclosed in the annual programmes.

University Capacity (1968 - 1972) (In Thousand)

Years	Science & Technical Subjects (Number) (1)	(%) (2)	Medicine (Number) (3)	(%) (4)	Agriculture (Number) (5)	(%) (6)	General (Number) (7)	(%) (8)	Total (Number) (9)	(%) (10)
1968 - 1969	33.0	26	13.3	11	6.3	5	73.3	58	125.9	100
1969 - 1970	38.6	29	14.6	11	7.1	5	74.8	55	135.1	100
1970 - 1971	45.5	31	19.2	13	8.2	6	76.3	50	149.2	100
1971 - 1972	54.2	33	23.2	14	9.4	6	77.8	47	164.5	100
1972 - 1973	64.9	36	27.7	15	10.6	6	79.3	33	182.6	100

Source : State Planning Organisation

TABLE 45. THE GROWTH OF TURKISH AGRICULTURAL AND TECHNICAL HIGHER EDUCATION (1968-1972)

From TURKEY (1969), p. 192.

	Years	1968 - 1969	1969 - 1970	1970 - 1971	1971 - 1972	1972 - 1973
	(1)	(2)	(3)	(4)	(5)	(6)
Architects & Civil Engineers	First Registrations	5,050	5,950	7,050	8,400	10,050
	Graduates	1,300	1,400	1,600	1,900	2,300
Mechanical Engineers	First Registrations	1,100	1,350	1,700	2,100	2,650
	Graduates	360	380	425	510	615
Electrical Engineers	First Registrations	705	845	995	1,195	1,445
	Graduates	255	260	255	295	345
Mining Engineers	First Registrations	330	400	490	590	700
	Graduates	130	145	175	210	245
Industrial Engineers	First Registrations	325	380	510	710	950
	Graduates				125	205
Textile Engineers	First Registrations	50	50	60	85	110
	Graduates				20	25
Other Engineers	First Registrations	120	170	225	290	360
	Graduates			15	35	60
Topographers and Cartographers	First Registrations	100	125	150	180	230
	Graduates	35	45	60	75	90
Agricultural Engineers	First Registrations	730	795	370	955	1,050
	Graduates	410	425	450	490	520
Forestry Engineers	First Registrations	365	415	470	530	595
	Graduates	170	190	205	225	255
Zoologists & Veterinarians	First Registrations	290	385	485	595	720
	Graduates	60	75	95	140	190
Physicists and Geophysicists	First Registrations	635	680	745	815	900
	Graduates	160	180	225	245	260
Chemists & Chemical Engineers	First Registrations	915	925	930	940	960
	Graduates	390	425	430	440	450

Source : State Planning Organisation

TABLE 46. COST PER STUDENT BY EDUCATIONAL LEVEL IN TURKEY (1968-1972)
From TURKEY (1969), p. 198.

(At 1965 Prices)

Educational Establishments	Building Investment to Create Capacity (1)	Educational Equipment Investment to Create Capacity (2)	Repair and Restoration Investment (3)	Cash Expenditure (Per Year) (4)
Primary Schools				
a. Day Students	1,000	100	30	250
b. Boarders	2,000	100	50	2,000 (Seasonal)
c. Regional Schools	4,000	100	50	1,000 (New)
Secondary Schools				2,000 (Seasonal)
(General)	2,000	300	50	1,000 (New)
High School				1,000
(General)	2,500	500	70	1,250
Agricultural				
Schools	4,000	1,250	125	2,000
Ancillary Medical				
Personnel Schools				
a. Boarders	6,000	3,500	250	3,500
b. Day Students	4,000	2,500	200	2,500
Village Midwife				
Schools	6,500	3,000	100	3,500
Technical Schools	4,500	4,750	300	2,000
Teacher Training				
Schools	7,500	1,500	150	3,500
Primary Teacher				
Training Schools	6,000	1,250	125	2,000
Higher Education				
a. Technical	7,500	7,500	400	8,000
b. Medicine	6,000	5,000	400	5,000
c. Agricultural	6,000	5,500	400	6,000
d. Other	4,000	1,500	300	3,500

Source : State Planning Organisation

TABLE 47. QUALIFIED SCIENTISTS AND ENGINEERS IN TURKISH RESEARCH INSTITUTES
From OECD (1969), p. 200.

Field	No. of Institutes	No. of top level R & D Personnel	Average per Institute
Agriculture	79	611	7.7
Engineering	33	198	6.0
Basic Sciences	33	206	6.0
Medicine	68	531	7.8
TOTAL	213	1 546	7.2

Source: Report on the Research Institute, TUBITAK, Ankara, May 196[illegible]

TABLE 48. TURKISH EXPENDITURE AND MANPOWER ESTIMATES BY MAIN RESEARCH SECTORS[1]
From OECD (1969), p. 199.

Sector	No. of Units	Researchers per Unit	Expend. (1964) (in millions of TL)	Research Scientists	Exp/Scient. in thous. of TL)	Exp/Res Unit, (in thous. of TL)
Higher Education of which:	360	7.7	24.2	2,787	8.7	67.2
Sc.Fac.	60	6.6	4.4	393	11.1	73.3
Med. "	151	10.7	10.2	1,616	6.3	67.5
Eng. "	71	5.5	5.7	390	14.6	80.3
Agr. "	78	5.0	3.9	388	10.1	50.0
Public Sector of which:	140		125 (2)	1,720	72.5	890
Agric.	100		75	900	83.0	750
Other (mainly engin.)	40		50	820	61.0	1,250
Private Sector	10		4.5	50	-	-
TOTAL	510		160	4,500	36	310

(1) The table is based on the following sources: (i) For research units and research scientists in the Higher Education Sector, unpublished studies of the TUBITAK Science Policy Division; (ii) For the Private Sector figures the TUBITAK survey; (iii) For the Public Sector situation and for expenditures, Pilot Team estimates based on TUBITAK figures and interviews; (iv) For Higher Education expenditures: Pilot Team compilation from budget data.

(2) Excluding certain institutes indicated in the global figure of the TUBITAK survey.

TABLE 49. TURKISH ENGINEERS WITH FOREIGN DEGREES AND WORKING ABROAD AS OF APRIL 1968
From CIMT (1970), p. 308.

Category	Total Number Registered	Holders of Foreign Degrees Number	Holders of Foreign Degrees Per Cent	Working Abroad Number	Working Abroad Per Cent
Civil Engineers:	5,257	602	11.5	187	3.6
Mining	1,264	260	20.5	11	0.9
Chemical	1,708	130	7.6	43	2.5
Electrical	2,356	380	16.1	231	9.8
Mechanical	3,527	890	25.2	176	5.0
Architects	3,121	182	5.8	327	10.6
TOTAL	17,233	2,444	14.2	975	5.6

Source: Records of TurkishChambers of Engineers and Architects.

TABLE 50. TURKISH LONG-RANGE MANPOWER DEMAND PROJECTIONS 1968-1982, IN THOUSANDS

From TURKEY (1969), p. 165.

Professions	1967	1968	1969	1970	1971	1972	1977	1982
I. Engineers	25.5	27.8	30.5	33.7	36.5	40.2	63.2	94.8
1. Architects and Civil Engineers	11.7	12.9	14.3	15.9	17.5	19.5	32.3	49.6
2. Mechanical Engineers	5.8	6.3	7.0	7.7	8.3	9.1	14.2	21.2
3. Electrical Engineers	3.1	3.2	3.4	3.7	3.9	4.2	6.1	8.8
4. Mining Engineers	1.8	1.9	2.0	2.2	2.3	2.5	3.6	5.1
5. Other Engineers	2.3	2.6	2.9	3.2	3.4	3.7	5.3	7.7
6. Topographers, Hydrographers and Cartographers	0.8	0.9	0.9	1.0	1.1	1.2	1.7	2.4
II. Scientists and Technicians	42.6	47.7	53.6	60.4	68.5	77.3	142.6	261.4
1. Construction Technicians	15.1	17.0	19.1	21.4	24.0	27.0	48.3	87.1
2. Mechanics	6.6	7.4	8.4	9.5	10.8	12.3	23.0	41.6
3. Electricians	4.5	5.1	5.7	6.7	7.6	8.4	16.1	29.8
4. Mining Technicians	0.5	0.5	0.6	0.6	0.8	0.8	1.2	2.2
5. Technical Draftsmen and Surveyors	2.0	2.2	2.5	2.9	3.7	4.6	12.0	26.4
6. Other Technicians	13.9	15.5	17.3	19.3	21.6	24.2	42.0	74.3
III. Agriculture and Forestry	13.6	15.8	16.9	18.0	19.2	20.4	29.0	43.0
1. Agricultural Engineers and Landscapers	4.4	4.6	4.9	5.1	5.4	5.7	7.6	10.3
2. Foresters and Architects	1.5	1.6	1.7	1.8	1.9	2.0	2.7	4.0
3. Veterinarians	1.6	1.7	1.9	2.1	2.3	2.5	3.8	5.8
4. Agricultural Technicians and Technical Workers	4.4	4.6	4.8	5.1	5.4	5.7	7.6	10.3
5. Forestry Technicians and Technical Workers	0.9	1.6	1.7	1.8	1.9	2.0	2.7	4.0
6. Animal Hygiene Officers	0.8	1.7	1.9	2.1	2.3	2.5	4.6	8.6
IV. Professions Related to Chemistry and Physics	4.8	5.0	5.5	5.9	6.4	6.8	9.2	11.8
1. Physicists, Geophysicists and Geologists	2.9	3.0	3.2	3.3	3.5	3.6	4.4	5.5
2. Chemists, Chemical Engineers and Chemical Technicians	1.9	2.0	2.3	2.6	2.9	3.2	4.8	6.3
V. Artisans	1,387.0	1,495.1	1,604.7	1,728.9	1,851.5	1,994.2	2,894.6	4,129.7
1. Blast Furnace, Rolling-mill, Forge and Foundry Workers	21.5	23.5	25.5	27.9	30.4	33.1	46.4	67.2
2. Machinery Production and Repair Shop Workers	279.1	297.1	316.6	339.2	363.6	391.5	562.7	799.1
3. Electrical Appliance Manufacture and Repair Shop Workers	44.5	48.2	52.2	56.6	61.5	66.9	101.0	147.9
4. Weavers and Other Related Vocations	196.8	208.6	221.5	234.4	248.2	263.5	354.9	484.3
5. Tailors, Furriers and Cobblers	274.4	293.6	309.1	324.6	341.4	359.7	470.2	626.1
6. Wood, Rush and Cane Crafts	173.2	190.4	204.4	218.7	234.6	252.2	372.0	530.6
7. Food, Beverage and Tobacco Production	121.7	129.5	136.9	144.8	153.2	162.2	214.4	286.7
8. Construction	166.0	186.1	209.1	240.6	263.6	295.9	509.8	797.3
9. Stone, Marble and Clay Crafts	41.5	50.1	56.3	63.3	70.8	79.2	136.4	212.7
10. Miscellaneous	63.3	68.0	73.1	78.8	84.2	90.0	126.8	177.8

Source : State Planning Organisation

TABLE 51. TURKISH LONG-RANGE MANPOWER SHORTAGE PROJECTIONS (1968-1982), IN THOUSANDS

From TURKEY (1969), p. 171.

Professions	1967	1968	1969	1970	1971	1972	1977	1982
I. Engineers	8.6	10.3	11.3	12.9	14.1	16.2	31.3	55.8
1. Architects and Civil Engineers	4.4	5.4	6.0	6.7	7.4	8.6	17.1	30.5
2. Mechanical Engineers	2.7	3.1	3.6	4.1	4.5	5.5	9.0	14.9
3. Electrical Engineers	0.9	1.0	1.0	1.2	1.5	1.3	2.5	4.5
4. Mining Engineers	0.5	0.6	0.6	0.7	0.7	0.9	1.6	2.8
5. Other Engineers	—	—	—	—	—	—	0.3	1.6
6. Topographers, Hydrographers and Cartographers	0.1	0.2	0.1	0.2	0.3	0.4	0.8	1.5
II. Scientists and Technicians	6.8	10.3	15.0	20.0	26.5	33.7	87.9	189.2
1. Construction Technicians	2.0	3.8	5.9	8.1	10.6	13.7	34.8	73.6
2. Mechanics	—	0.5	1.1	1.8	2.7	3.8	12.6	29.5
3. Electricians	—	0.5	1.1	2.1	3.0	3.7	11.3	25.0
4. Mining Technicians	0.2	—	0.1	0.1	0.3	0.3	0.7	1.6
5. Technical Draftsmen and Surveyors	1.2	0.8	0.5	—	—	—	—	—
6. Other Technicians	3.4	4.7	6.3	7.9	9.9	12.2	28.5	59.5
III. Agriculture and Forestry	3.8	5.1	5.5	5.8	6.2	6.6	11.6	22.1
1. Agricultural Engineers and Landscapers	—	—	0.1	0.1	0.1	0.2	1.0	206
2. Foresters and Architects	0.1	0.1	0.2	0.2	0.2	0.2	0.5	1.4
3. Veterinarians	—	—	0.1	0.3	0.4	0.5	1.5	3.2
4. Agricultural Technicians and Technical Workers	2.5	2.4	2.3	2.3	2.4	2.4	3.2	4.8
5. Forestry Technicians and Technical Workers	0.8	1.4	1.4	1.4	1.4	1.5	1.7	2.6
6. Animal Hygiene Officers	0.4	1.2	1.4	1.5	1.7	1.8	3.7	7.5
IV. Professions Related to Chemistry and Physics	0.1	0.1	0.3	0.4	0.5	0.5	0.8	1.6
1. Physicists, Geophysicists and Geologists	0.1	0.1	0.2	0.3	0.4	0.4	0.6	1.3
2. Chemists, Chemical Engineers and Chemical Technicians	—	—	0.1	0.1	0.1	0.1	0.2	0.3
V. Artisans	101.0	174.0	249.6	337.5	421.2	522.3	1,133.4	1,866.0
1. Blast Furnace, Rolling-mill, Forge and Foundry Workers	2.7	3.9	5.0	6.6	8.3	10.0	19.3	36.4
2. Machinery Manufacture and Repair Shop Workers	26.1	31.8	39.8	49.8	60.5	73.5	142.7	187.2
3. Electrical Appliance Manufacture and Repair Workers	4.3	5.3	7.0	8.9	11.3	14.0	31.8	50.5
4. Weavers and Other Related Vocations	13.8	25.2	37.7	50.0	62.9	77.2	158.6	264.3
5. Tailors, Furriers and Cobblers	2.7	3.6	17.9	26.3	35.9	47.0	120.3	229.9
6. Wood, Rush and Cane Crafts	10.0	23.8	34.8	46.0	58.7	73.2	177.9	322.5
7. Food, Beverage and Tobacco Production	11.0	18.3	25.0	32.3	40.0	48.4	97.2	165.7
8. Construction	187.8	32.6	49.3	73.9	89.4	113.5	257.6	413.8
9. Stone, Marble and Clay Crafts	4.9	13.2	19.0	25.6	32.8	40.8	96.0	170.2
10. Miscellaneous	6.8	10.3	14.1	18.1	21.4	24.7	32.0	27.5

Source : State Planning Organisation

TABLE 52. TURKISH RESEARCH AND DEVELOPMENT EXPENDITURES - 1964
From OECD (1969), p. 197.

Sector	Expenditure in mil. of T.L.
Public Sector (including S.E.E.)	212.8 million TL
Higher Education Sector	30.1 million TL
Private Sector	4.5 million TL
TOTAL	247.4 million TL

Source: Report on the Research Institute, TUBITAK, Ankara, May 1966.

TABLE 53. THE BUDGET OF TUBITAK (Turkey)
From OECD (1969), pp. 298-299.

Income (thousand TL.)	1965	1966
Subsidy from the Prime Minister's Office:		
- for current expenditure	3,500	3,000
- for investment expenditure	3,500	2,000
Transfer from previous year's budget	2,630	5,214
Interest	85	150
Income from Research	-	50
Foreign assistance*		454
	9,715	10,868

* Mainly in the form of technical assistance from various international organisations such as OECD, NATO, etc.

Expenditure Budget (thousand TL.)	1965	1966
Administrative expenditure	3,500	2,690
Personnel	2,836	2,100
Other	664	590
Research expenditure	4,885	3,754
Training expenditure	1,330	2,072
Science prize	-	50
Documentation Centre expenditures	-	600
Research Centre	-	1,702
	9,715	10,868

TABLE 54. TURKISH RESEARCH EXPENDITURES IN THE PUBLIC SECTOR - 1964
From OECD (1969), p. 215

1. Department of Construction and Reconstruction, Ministry of Public Works	845,150 TL
2. Department of Railways and Ports, Ministry of Public Works	280,00 TL
3. Department of Airports and Fuel Installations, Ministry of Public Works	500,000 TL
4. General-Directorate of Highways	5,700,000 TL
5. General-Directorate of State Hydraulic Works	4,456,000 TL
6. Machinery and Chemical Industry	1,906,000 TL
7. The Iron and Steel Works of Karabük	Nil
8. The Nuclear Energy Research Centre at Küçükçekmece	4,845,177 TL
9. Ministry of National Defence	1,048,000 TL
10. Ministry of Agriculture	75,000,000 TL
11. The Soil Products Office	30,055 TL
12. The Sugar Industry	8,759,565 TL
13. The Meat and Fish Industry	Nil
14. General-Directorate of Meteorological Works	1,000,000 TL
15. Directorate of Etibank Electrical Works	300,000 TL
16. Other research activities of Etibank	646,900 TL
17. The Cement Industry Co. Ltd. of Turkey	448,845 TL
18. Ministry of Health and Social Welfare	5,500,000 TL
19. Ministry of Reconstruction and Resettlement	12,314,150 TL
20. Sümerbank	161,000 TL
21. General-Directorate of Turkish Monopolies	438,000 TL
22. The Scientific and Technical Research Council of Turkey	3,500,000 TL
23. Institute of Hydrology, Faculty of Science, Istanbul University and the Food Conservation Research Institute of Bursa	470,000 TL
TOTAL	212,897,842 TL

Source: TUBITAK, *Report on the Research Institute*, *op.cit.*

TABLE 55. BILATERAL LINKS
From LOMAN (1969)

Recipient: BRAZIL

Donor	G	A	E	S	H	AT	I	TOT
Canada								
France		1	2					3
Germany		4	3	4	1			12
Italy					1	1		2
Japan								
Netherl.								
Spain						1		1
Switzerl.						1		1
U. K.								
U. S.		4	1½	2½	1		5	14
Sum		9	6½	6½	3	3	5	33
G	0							
A		9						
E			6½					
S				6½				
H					3			
AT						3		
I							5	
TOT								33

Recipient: INDONESIA

Donor	G	A	E	S	H	AT	I	TOT
Canada								
France								
Germany								
Italy								
Japan								
Netherl.								
Spain								
Switzerl.								
U. K.								
U. S.	1	1⅓	⅓	⅓	1			4
Sum	1	1⅓	⅓	⅓	1			4
G	1							
A		1⅓						
E			⅓					
S				⅓				
H					1			
AT						0		
I							0	
TOT								4

Recipient: S. KOREA

Donor	G	A	E	S	H	AT	I	TOT
Canada								
France								
Germany								
Italy								
Japan	1							1
Netherl.								
Spain								
Switzerl.								
U. K.								
U. S.		⅓	⅓		⅓	1		2
Sum	1	⅓	⅓		⅓	1		3
G	1							
A		⅓						
E			⅓					
S				0				
H					⅓			
AT						1		
I							0	
TOT								3

Recipient: NIGERIA

Donor	G	A	E	S	H	AT	I	TOT
Canada			1					1
France								
Germany	3	2		3	1			9
Italy								
Japan								
Netherl.		1						1
Spain								
Switzerl.								
U. K.	3	1		3	1		1	9
U. S.		5	3½	1½	1½			11
Sum	6	9	4½	7½	3		1	31
G	6							
A		9						
E			4½					
S				7½				
H					3			
AT						0		
I							1	
TOT								31

Recipient: TURKEY, and ALL recipients

Donor	G	A	E	S	H	AT	I	TOT	ALL
Canada									1
France									3
Germany		5	6	1				12	33
Italy									2
Japan									1
Netherl.			1					1	2
Spain									1
Switzerl.									1
U. K.									9
U. S.		½	2½			1		4	35
Sum		5½	9½	1		1		17	88
G	0								8
A		5½							25½
E			9½						21⅙
S				1					15⅓
H					0				7⅓
AT						1			5
I							0		6
TOT								17	88

G = General
A = Agriculture
E = Engineering
S = Science
H = Health
AT = Atomic Energy
I = Industry
TOT = Total over all fields

TABLE 56. A MEASURE OF SCIENTIFIC OUTPUT

	BRAZIL	INDONESIA	S. KOREA	NIGERIA	TURKEY	(U.S.)
No. of Sci. Authors Cited (From PRICE (1969))	206	14	22	97	58	(52000)
Same Per Million Population (1967)	2.40	0.12	0.74	1.90	1.78	(270)

TABLE 57. KOREAN PATENT STATISTICS
From KOREA (1972c), pp. 94, 95, 96, and 101.

Patents by Field

Unit : Number

Field \ Year	64	65	66	67	68	69	70	71
Machinery	58	142	123	144	207	206	260	198
Chem. ind.	291	296	286	347	423	499	658	540
Textiles	91	79	71	87	112	160	155	128
Elec. Com.	48	66	64	66	121	186	253	214
Civil Eng. and Arch.	34	51	56	61	69	115	150	102
Mining and Metal	60	52	71	54	59	67	97	93
Food and Sanitation	261	236	284	284	312	370	209	374
Printing	29	35	31	47	56	67	23	54
Agricultures	8	46	54	44	54	30	23	56
Miscellaneous	28	15	22	43	60	—	15	148
Total	908	1,018	1,060	1,177	1,463	1,699	1,846	1,906

Source : The Bureau of Patents

Research Expenditures per Invention

Unit: $ Thousands

Nation	R & D Exp.	Nation	R & D Exp.
U.S.A. (68)	373.3	Italy (67)	83.3
U.K. (67)	89.4	Japan (68)	30.0
W. Germany (67)	69.4	Korea (70) (71)	28.2 23.6
France (68)	157.2		

OECD
Source: The Bureau of Patents and OECD

Notes: Research Exp. per Invention = $\frac{\text{Total R \& D Exp.}}{\text{No. of Patent Applications (Utilities excluded)}}$

Industrial Property Applications

Unit : number

Year \ Classification	Patents	Utilities	Designs	Trade Marks	Total
1963	771	1,790	729	1,295	4,585
1964	908	2,214	804	1,845	5,801
1965	1,018	2,849	825	2,053	6,745
1966	1,060	3,252	1,338	2,752	8,402
1967	1,177	3,594	1,919	3,228	9,918
1968	1,463	5,129	3,277	6,619	16,488
1969	1,699	5,567	4,536	9,106	20,908
1970	1,846	6,157	4,522	5,124	17,659
1971	1,906	6,810	5,348	5,816	19,880

Source : The Bureau of Patents

TABLE 57. KOREAN PATENT STATISTICS (cont.)

Patent Applications by Foreigners

Unit : Number

Year / Nation	64	65	66	67	68	69	70	71
U. S. A.	122	87	67	183	230	366	305	337
U. K.	6	5	7	16	13	26	72	54
Denmark	—	—	—	1	2	—	4	5
W. Germany	11	22	51	49	62	76	137	102
Switzerland	16	30	38	53	34	40	47	66
Italy	7	1	1	5	9	5	27	17
Norway	—	1	2	—	—	—	1	1
Malaysia	—	1	—	—	.	—	—	—
Australia	1	—	—	—	1	3	4	2
Hong Kong	—	—	—	—	—	2	—	—
Netherland	—	8	5	4	3	12	19	19
Sweden	—	—	—	—	—	2	5	8
France	1	7	6	10	14	13	11	8
Panama	—	—	—	—	1	1	-	2
Canada	—	1	2	1	1	8	7	2
Korean Abroad	—	—	—	—	—	2	5	—
	—	—	—	—	—	—	—	1
Total	164	160	177	322	[illegible]	547	616	643

Source : The Bureau of Patents

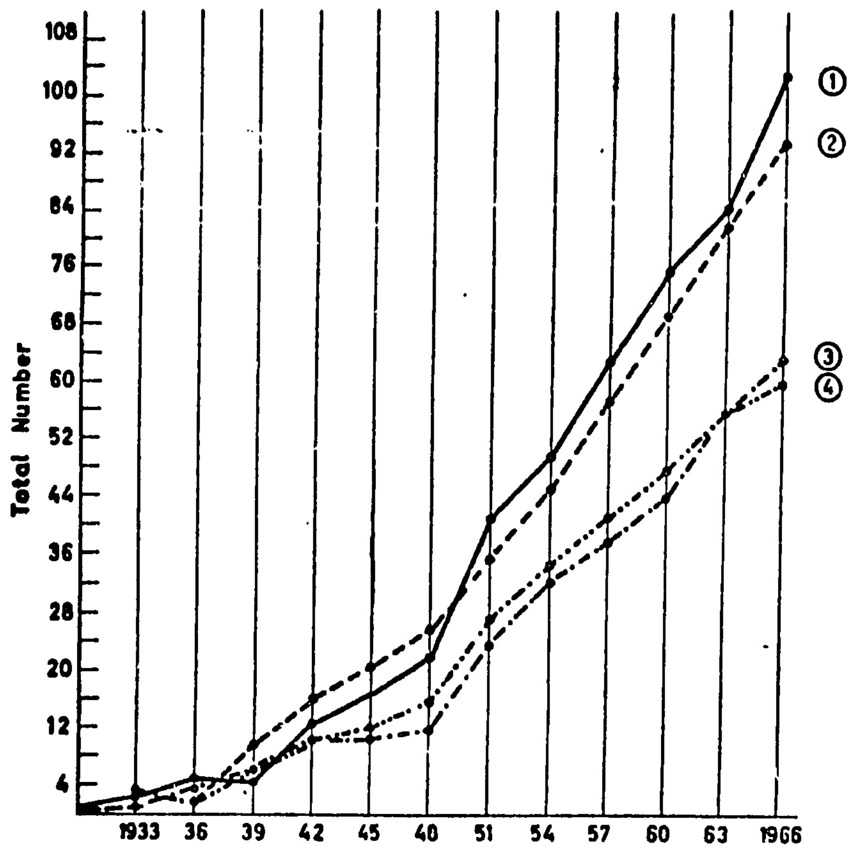
Patents Registered

Unit : Number

Year / Nation	64	65	66	67	68	69	70	71
Total	213	289	255	428	359	317	266	229
Domestic	147	175	191	272	207	200	190	192
Foreigner	66	113	65	156	152	117	76	37
U. S. A.	44	86	42	81	69	65	50	18
U. K.	4	4	3	10	3	4	1	—
W. Germany	6	8	8	24	43	25	12	13
Denmark	1	—	—	—	--	—	—	—
Norway	—	—	—	2	1	—	—	—
Italy	5	8	3	2	1	2	—	—
Switzerland	6	6	7	28	29	29	8	4
China, Rep. of	—	—	—	—	--	—	—	—
France	—	—	1	3	1	1	1	—
Netherland	—	1	—	6	3	—	4	2
Canada	—	1	—	—	—	1	—	—
Australia	—	—	—	—	1	—	—	—
Panama	—	—	—	—	1	—	—	—
Korean Abroad	—	—	—	—	—	3	2	—

Source : The Bureau of Patents

FIGURE 1. Total number of scientific personnel in various basic sciences in Turkey. Includes all scientists with at least a Ph.D. degree.



Legend:

Chemistry (1)
Biology (2)
Physics (3)
Mathematics (4)

From OZINONU (1969), p. 150.